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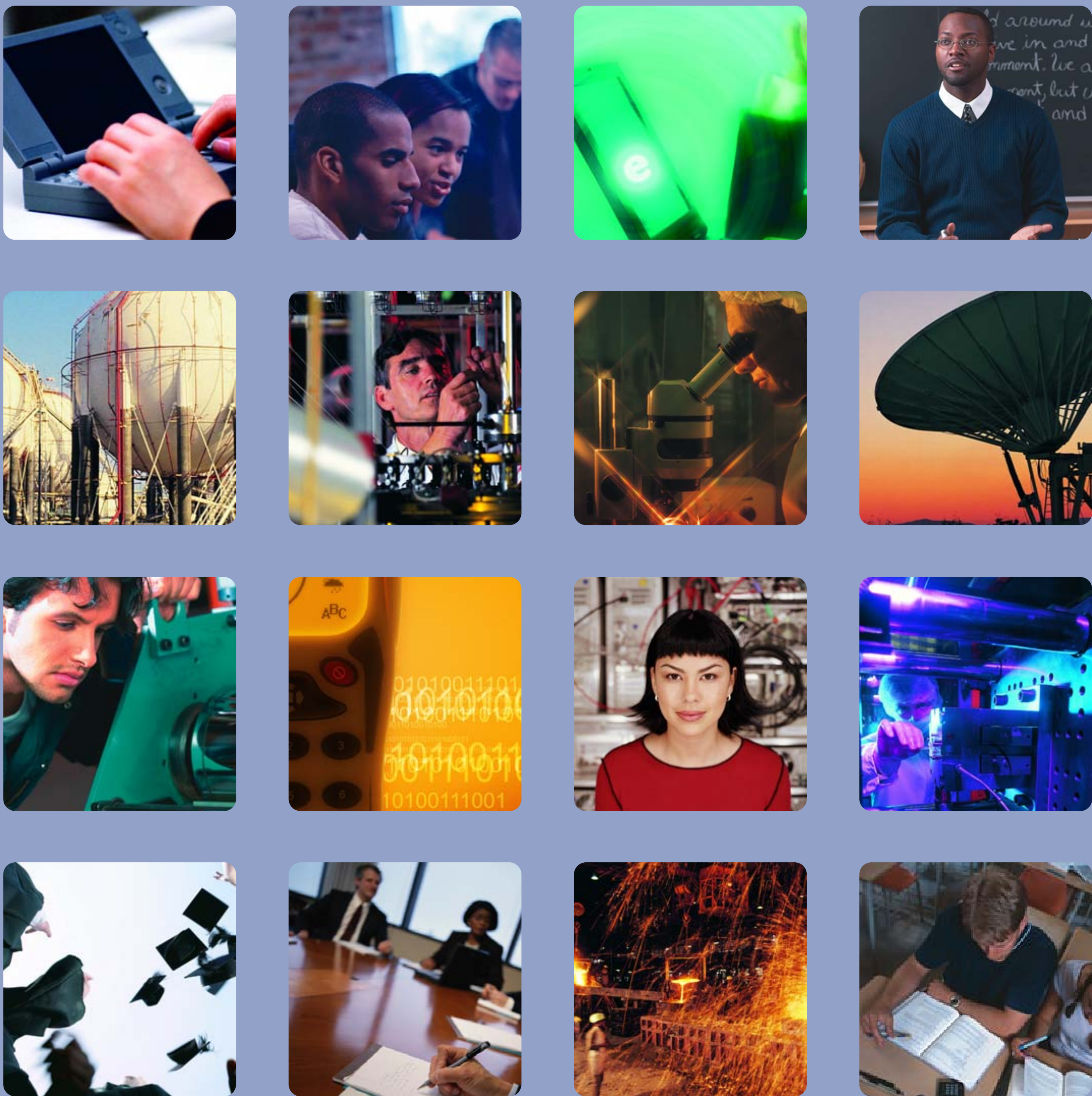
Digest of Engineering Statistics 2003/4

Report
July 2004



What have engineers ever done for us?

All right, but apart from the wheel, powered flight and those clever little springy things that walk down the stairs, what have engineers ever done for us? Have your say at www.scenta.co.uk/argument - where engineers from all disciplines are coming together for the first time in history.

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Progress through partnerships

Contents

Forward

...SET-intensive sectors in the UK contributed towards 27.1% of the total change in labour productivity over the period 1993 to 2000

This is the seventh in a series of annual statistical digests published by the Engineering Council (UK) and the Engineering and Technology Board (etb). It is intended as a valuable reference for everyone interested in the large and ever-broadening science, engineering and technology (SET) community. Each edition has built on the previous one. Each year more data and analysis has been added and this issue is no exception.

The current period of technological change is probably the deepest and most rapid of any in the last thousand years and professional engineers, scientists and technicians are playing a crucial role in this important and exciting process. While still failing to attract enough of the brightest and the best of today's youth, engineering is nevertheless one of the few disciplines to offer near certainty of employment for today's graduates together with the high probability of a good quality job. The major traditional engineering functions of manufacture and construction offer rewarding careers, but the higher salaries are often found in telecommunications, information technology, chemical engineering and electrical engineering – or even outside engineering, where the demand for articulate, numerate problem-solvers remains unabated.

The academic standard of those entering university to study engineering and science continues to rise slowly. However concerns continue about falling numbers of NVQ/SVQ awards and HND/HNC registrations in further education (Chapter 3). And concerns also exist about falling numbers of those studying A-level Mathematics, Physics and Chemistry (Chapter 2) and those intending to study Mathematics, Engineering and the Physical Sciences at our universities and colleges (Chapter 4).

As in previous years not only has the data been up-dated whenever possible but new data has been added; this year a lot of the new data has arisen because of the considerable amount of research commissioned by the etb in 2003. Any useful statistics resulting from this research have been placed in this edition. Thus Chapter 1 now has information on the perceptions of engineering and science held by teachers; and other etb sponsored research has suggested ways to improve the approach to careers advice and guidance. Chapter 6 now has time-series data for all three categories of registrants of working age, extracted from the EC (UK) registrant database. Chapter 8 also has new statistics arising from etb sponsored research and here can be found data on the employment of technicians by main economic sector and analyses of those with SET qualifications by gender and ethnicity. There is also a Background Data Annex extracted from a report by the Institute for Employment Studies, University of Sussex, Brighton; this data rich annex contains employment data by occupation and by qualification not only analysed by gender and ethnicity but also by other dimensions, including type of degree, age band and region of work.

Finally Chapter 9, which explores the role of engineers and scientists in the process of economic growth, now has additional data on productivity, competitiveness and the role of SET in the current economic activity of the UK; and also an empirical analysis on the contribution of SET and technology to economic growth and to the growth of labour productivity in the UK, Germany, France and Japan, following the completion of path breaking research undertaken by London Economics for the etb. This research used growth accounting techniques and the report was published in March 2004.

A copy of this publication together with the detailed statistical and reference material on which it is based appears on the web sites www.engc.org.uk and www.etechb.co.uk

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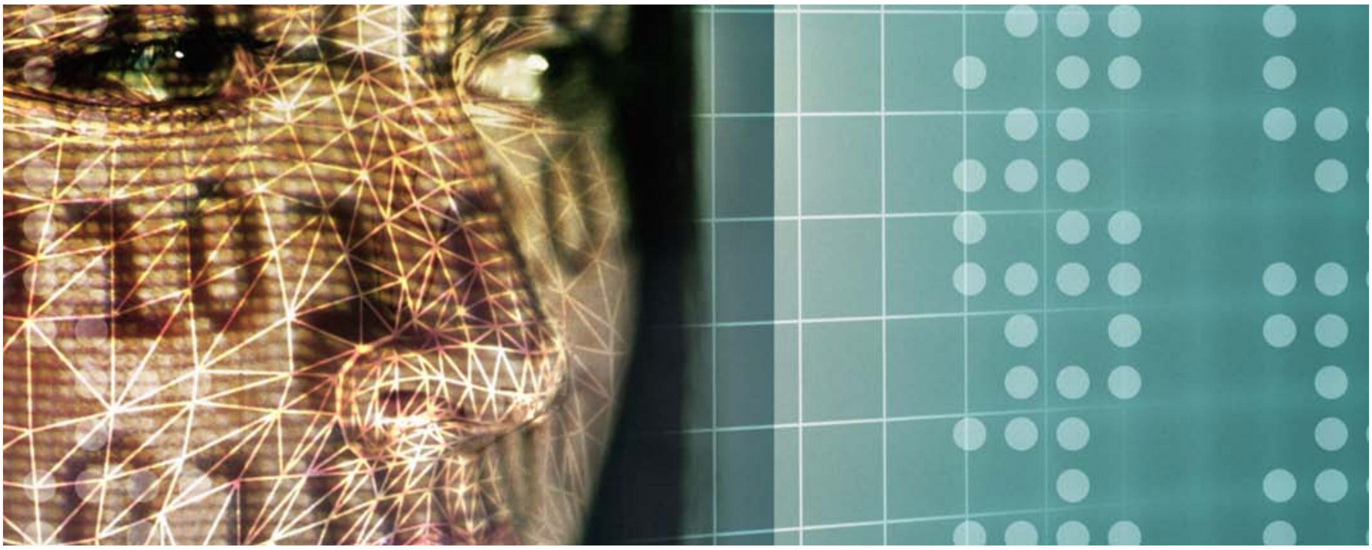
Summary



In a 2001 European Union report, engineering was found to be one of the most highly regarded professions in Europe. These findings were mirrored in the United Kingdom.

2. Secondary education

GCSE awards in Mathematics have numbered over 700,000 in recent years, with over a half of these now marked at grade C or above. Since 1995 Physics awards have been in the range 45 – 48,000 with nearly 89% achieving in 2003 Grade C or above.

Science Double Awards remain popular with young people in maintained schools, with 560,000 awards given in 2003 (although the number of candidates is half this). Chemistry GCSE awards have been around 46 – 49,000 in recent years.

The number of GCSE awards made in Information Technology has been expanding rapidly in recent years, rising from 70,566 in 1997 to 116,033 in 2002, an expansion over this period of 64%. There was a decline recorded in 2003, but this was more or less compensated by a rise in the number of GNVQ Intermediate awards from 22,734 in 2002 to 45,612 in 2003. Computing is clearly popular with young people at school.

The trends at A level for Science and Technology subjects (SET) have been less favourable. Over the last 10 years for example awards in Mathematics have fallen by 16%, Physics by 22% and Chemistry by 15%.

On the other hand, however, Computing A level awards have rise by 175%, while Biology awards have risen by 5% over the same ten year period.

Women entrants in 2003 represented 37% of A level Mathematics awards, 23% of those in Physics, 52% of those in Chemistry, 37% of those in Design and Technology, 26.5% of those in Computing but 62% of those studying Biology at A level.

As women entrants achieve a proportion of grades A-C in at least the same proportion or somewhat above that of men,

1. Perceptions of engineering as a career

One in seven pupils at secondary school would choose a career in engineering, though the majority of these were boys: only 1% of girls definitely wanted to become professional engineers. Most pupils do feel, however, that engineering is important to everyday life.

By age 17, about 7% of pupils appear to choose engineering as a career; role models appear influential. In the minds of pupils, engineering has a "negative image", based on the view that it is dirty, manual, intellectually undemanding work or even "boring" work.

Decisions about jobs are made generally at an early stage. By late primary school most pupils have rejected most jobs on the basis of their perception. But there is also evidence that as pupils become older they get more "realistic" about job choices and engineering becomes a slightly more popular choice of career.

Recent etb research expressed concern about the school curriculum and suggested that it should be more linked to every day debates and technologies and less based on abstract theories. The latter could be off-putting to children who would have otherwise followed a career in science or technology.

etb research last year also concluded that the role of careers advice has limited impact due to the strong influence of parents, friends and the media. However, careers advice could be better organised.

The Public Attitudes to Science, Engineering and Technology Survey results were published in 2000. Comparing this with the Finniston Report Survey of 1978, it would appear that there has been a welcome change in attitudes regarding careers for young females in engineering.

Public perceptions of professional engineering were very favourable in both 1978 and 2000. Young people today may, however, be less informed about engineering than they were in the 1970's.

then there seems to be no educational reason why women should not take up similar proportions in SET subjects at undergraduate level.

3. Post-16 vocational education and training

In 2000 the FEFC reported that in 1998-99 there were 53,326 full-time and 228,592 part-time engineering students in further education colleges and other institutions funded by the FEFC. These figures included students found in further education colleges that were not funded by the FEFC.

Engineering is widespread in FE, and FEFC also found that in 1998-99 85% of colleges in the in the FEFC sector had course in engineering and technology compared to 76% of colleges in 1996. The trend is for majority of engineering courses to be concentrated in fewer colleges, in particular those colleges (representing about a fifth of the sector) which have over 1,000 enrolled engineering students.

The number of Advanced Level GNVQs awarded in engineering rose from 1,390 in 1999 to 1,515 in 2000. However, as the Roberts Review pointed out in 2002, although the numbers taking GNVQ in science, ICT and engineering have increased on the last few years these number are small in relation to, for example the 35-40,000 pupils who take A level Chemistry.

The latest QCA data shows that by September 2002 a total of 394,783 NVQ/SVQ certificates had been awarded in Engineering, with a further 304,526 in Construction, making up 10.2% and 7.9% respectively of all such awards.

There have been signs in recent years of a decline in the granting of NVQ/SVQ awards, with the amount each academic year falling at most levels from the peaks recorded in 1996-97. This decline may be due to the requirement for a separate demonstration for key skills; employers and trainees find this to be quite irrelevant to the job and as a result increasing numbers of potential NVW/SVQ holders simply do not complete.

The total number of starts for Advanced Modern Apprenticeships (AMAs) in 2001-2002 was 59,300, of which Engineering Manufacturing contributed 10%, the Motor Industry another 10% and Construction another 5%. Also in 2001-02 69% of people on an AMA in Engineering Manufacturing gained a full qualification at level 3 or above, while corresponding figures for Construction and the Motor Industry were 64% and 60% respectively.

One problem with work based learning is the relatively low overall 42% success rate for LSC funded work based learning in engineering, technology and manufacturing recorded in 2001/02; success rates include those who either meet all the requirements of their apprenticeship framework or who achieve an NVQ required by the framework. This compares unfavourably with the 56% gaining a qualification in engineering, technology and manufacturing in LSC funded colleges. In some cases non-completion may be the result of conscious choices by the apprentice and employer; in other cases non-completion will be related to the underpinning knowledge issue and a lack of enthusiasm amongst trainees and employers for the release from work that is necessary for the trainee to obtain a full award.

Numbers taking qualifications leading to registration for HNC/HND courses are slipping. The EdExcel-BTEC registration figures and the registration for HNC/HND courses certainly suggest this. But, many of those taking HNC/HND courses are encouraged to complete a degree at, or franchised by, a local university. This tends to inflate both HND and degree completions, while disguising the fall in HNC/HND diplomates to industry.

4. Higher education

The UK has seen an enormous expansion of its higher education system over the last 15 years during which the number of undergraduate entrants has risen by over one-and half times from 119,626 in 1988 to 316,242 in 2003, increasing from approximately 14% to 41% of the 18-year old population. The introduction of tuition fees does not seem to have significantly deterred young people from entering higher education.

The number of acceptances of UK students to Engineering fell over the years 1993 to 2001 but in 2002 (17,566) and 2003 (16,995) there have been signs that a levelling may now be occurring. But Engineering now attracts only 5.4% (2003 entry) of the total cohort. Given the declining numbers taking A level Maths and Physics these general trends are not surprising.

But admissions to Computing have seen a significant rise, increasing over threefold to 20,335 over the ten years to 2001. However, the number fell to 18,719 on 2002 entry and to 16,998 in 2003. Its market share is now the same as for Engineering at 5.4%.

Biological Sciences home acceptances increased from 13,916 in 1994 to 20,463 in 2003; this excludes Sports Science which was classified as a biological science for the first time in 2002, accounting for as much as 6,196 acceptances in 2002 and 6,716 in 2003.

Apart from Computer Sciences the other main disciplines have recorded declines. Mathematical and Physical Sciences home acceptances declined slightly by 7% from 17,778 in 1994 to 17,261 in 2003 while Engineering and technology fell by 13% over the same period from 19,156 in 1994 to 16,995 in 2003. However, it could be argued that 1993 and 1994 were exceptional years, prompted by the merging of the universities and polytechnics funding agencies with greater funding suddenly available to former polytechnics for engineering programmes.

Overall, women constituted only 13% of applicants accepted to Engineering and Technology degree courses in 2002 according to UCAS data, and this proportion has remained largely unchanged since 1991. The proportion varies by engineering discipline, however; women made up 23% of Chemical Engineers and 7% of Mechanical Engineers. The proportion of female acceptances to Mathematical and Physical Sciences in 2003 was 40% while it was much lower than this in Computer Science at 17%, and, of course, in Engineering and Technology where it was 13%. However, the Biological Sciences seem to appeal to females as 65% of acceptances in 2003 were female when Sports Science is included.

The “non-continuation rate” or “drop out” rate for Engineering fell from 11% in1997-98 to 9% in 2000/01 for young entrants to full time courses. In 2000-01 the non-continuation rates were 7% for all subjects, 6% for the biological and physical sciences and 8% for the mathematical and computing sciences.

China and Japan produce vastly greater numbers of Engineering graduates than do other countries (199,354 and 103,440 respectively, 1999). But the EU-15 produced in total 134,602 Engineering graduates at the same time.

When the number of Engineering graduates is expressed as a percentage of 24 year olds, the position in the UK relative to many other countries looks quite favourable in resource terms. Finland heads the list at nearly 7%, with the UK 7th at 3%, the USA 14th at 2% and China last at 0.9%.

The UK educates more graduates than any other country in the EU-15, and more Engineering graduates than any other country in the EU-15 except Germany.

However, the USA and the UK are unusual perhaps in producing a significantly larger number of Natural Science than Engineering and Technology graduates. Also when the number of Engineering and Natural Science graduates is expressed as a proportion of the number of 24 year olds, China fall to the bottom of the league (at 21st), while the UK comes 1st and the USA 13th.

5. Graduate employment

When graduates leave higher education today, the labour market environment and their financial position in less favourable than it was 10 or 20 years ago. Student debt levels continue to rise and reached an average of £6,507 for all graduates and £7,695 for engineering graduates in 2000 and were projected to reach an average of £12,000 for all graduates and £14,000 for engineering graduates by 2002.

Evidence has emerged in recent years that it is proving harder to encourage UK graduates to undertake a PhD in engineering (or science). The Roberts Review in 2002 came to the same conclusion when it stated that “PhD study is financially unattractive in the short run. The gap between PhD stipends and the starting salaries of able graduates has increased dramatically over the last 25-30 years and more recently this has been exacerbated by increasing levels of undergraduate debt”. It can be anticipated that the effect of student funding system changes made recently may have a more severe effect of engineering than in many other disciplines.

Graduates’ first jobs are more likely to be temporary, part-time or of “non-graduate” nature than there were, as graduates are pressurised into taking any employment they can find which brings income. However, according to the Higher Education Statistics Agency, in 2001, 63% of Computer Science graduates entered full-time employment within 6 months of graduating. Engineers were not far behind at 62%. Overall 57% of all new graduates were in full-time employment. But the economic slowdown and the recession in manufacturing which occurred in 2002 meant that the proportion of 2002 engineering graduates entering full-time employment was down to 58%; and proportion of all graduates and computer science graduates were the same at 55%.

A large proportion of new 2002 Engineering graduates were employed in professional positions – 45% but down from the 51% recorded a year earlier.. This contrasts with only 25% of the total new graduate population.

The DTI/Barclays first destination study found that new engineering graduates and computer science graduates earned 29% and 14% respectively more than the typical graduate salary of £14,000 6 months after graduating in 2002. 51% of engineering graduates earned a high salary, defined at this stage as £18,000 per annum or more; this compared to 21% of the whole sample of graduates. Graduates, when asked, expected to earn, on average, £25,000 in 5 years time; engineering graduates’ expectations were about 20% higher than this.

The DTI/Barclays National Graduate Tracking Survey 2003 was published in November 2003; it reported that, after about three and a half years, respondent graduates as whole earned a median salary of £23,000 p.a. while engineering graduates earned £24,000 and computer science graduates earned a median of £22,000. 87% of all graduates were in full-time employment; this compared to 94% of engineering graduates. Engineering, one of three key groups examined were more likely to be in a job related their career, in a graduate job, a member of a professional society and earning a higher salary.

“Moving On”, another recent longitudinal study, found that 31% of engineering graduates end up participating in master’s courses, the highest proportion of any other discipline except natural sciences (33%).

Rates of return to higher education studies, which balance the investment of time, effort and money spent while studying relative to likely future increased income prospects, usually indicate a higher rate of return for graduates investing in courses on engineering and mathematics (and law and economics), rather than courses in arts and languages.

6. Professional registration

Over the last ten years, the number of Chartered Engineers has fallen from 197,375 to 190,402 by end 2003. Thus the number of Chartered Engineers fell by a compound rate of 0.4% per annum to 190,402 over the last ten years, while the number of Incorporated Engineers fell at a compound rate of 1.95% per annum to 45,192 and the number of Engineering Technicians fell at a compound rate of 1.9% per annum to 12,824 over the same period.

The number of Chartered Engineers of working age (under 65) is estimated to have fallen by 1.3% per annum over the period 1988 to 2003; this is a higher rate of decline than for Chartered Engineers as a whole and reflects the increase in the average age of Chartered Engineers over the same period. Data for the number of Incorporated Engineers and Engineering Technicians of working age for the same period of 1988 to 2003, suggests that declines of 2.7% and 2.6% per annum have been occurring.

At end-2003, only 3.2% of Chartered Engineers, 1.0% of Incorporated Engineers and 1.2% of Engineering Technicians were women. These figures are increasing, but only very slowly. But the proportion registered can be expected to rise slowly in the coming years as between 5-6% of all engineering and technology graduates working are

female and the proportion a UK females entering universities and colleges to study engineering and technology has been between 13- 15% since 1991.
According to the last 4 surveys of registered engineers, nearly 3% of respondents described their ethnicity as other than “white”.

Other data, albeit limited, suggests that the UK has about the same number of registered engineers as other developed countries when seen in the context of registered engineers as a percentage of the population and as a percentage of engineering graduates.

The main reasons that members of the institutions become registered engineers according to the 2002 Survey of Registered Engineers appear to be “Recognition of my professional achievement/qualifications/status” (49.5%), “To help with my career developments/promotions” (31.8%) and “To improve my job prospects/membership required by the prospective employers” (18.6%).

By November 2003 there was a Europe-wide total of 27,607 European Engineers, of whom 14,143 were from the UK. France had a total of 2,540, Spain 2,477 and Germany 2,429.

7. Employment conditions

Continuing low unemployment within the profession indicates a continuing high level of market demand.

According to the ONS New Earnings Survey the average annual gross earnings (including overtime) for all those classified as professional engineers and technologists was £33,324 in the year ending April 2002. By contrast, the average annual gross earnings (including overtime) for registered Chartered Engineers in the year to April 2003 was £49,088 according to the Engineering and Technology Board 2003 Survey of Registered Engineers. This rather large difference between the national data and the survey response from the profession could stem from a number of causes. However, one of the reasons must be that registered engineers earn considerably more than the national average for the equivalent Standard Occupational Classification (SOC).
The median Chartered Engineer salary was £43,477 in the year to 5 April 2003, while for Incorporated Engineers it was £34,000. Engineering Technicians’ median salary is now £29,000, an increase of 1.8% on the 2002 figure.

The evidence from the 2001 Survey of Registered Engineers indicates more marked differences between disciplines amongst Chartered Engineers. For examples, Chartered Engineers who were members of the Institution of Civil Engineers earned an average and median of £42,260 and £36,000 respectively compared to those who were members of the Institution of Chemical Engineers - £59,479 and £46,037 respectively.

For engineering occupations in general supply appears to be more or less equivalent to demand. However there are specific shortages documented from responses by employers. In engineering manufacture there seems to be a shortage of professional engineers in the electronics sector and elsewhere in construction. The demand for civil engineers and other engineers in construction is very strong, but still not fully reflected in relative salaries. However construction is a highly cyclical industry and has been responding to a boom in transport-related work and the strength of the property market.

Superimposed on the picture of relative balance is the apparent dissatisfaction of employers with the skills that graduates have. A constant theme over past years has been a demand for "high calibre" graduates. The Skills Dialogue report found that the skills the engineering employers had most difficulties finding in professional engineers included, firstly, technical and (other) practical skills; then advanced IT and software skills; and thirdly problem solving skills in order of difficulty. However generally high levels of proficiency were reported amongst all occupations including professional engineers.

Very few studies have really addressed sector specific needs in terms of technical and practical skills. The EMTA 2002 Labour Market Survey found that the most frequently mentioned skills gaps, when also exploring technical deficiencies, were for CNC machine operation (21%), assembly line/production robotics (9%) and general engineering (8%).

One of the main findings of the 2002 EMTA Labour Market Survey was that the labour market was generally less buoyant than in the previous 1999 and 1998 surveys. But the 2002 survey still found significant hard-to-fill vacancies and skills gaps in the engineering manufacturing industry.

In 2003 the Engineering and Technology Board published research which looked at, among other things, the skill requirements of small and medium sized enterprises (SMEs) in the manufacturing sector and the nature of skills gaps and the reasons why they occur amongst SMEs in the manufacturing sector.

Perceived skills gap were found to be far more in evidence in relation to the higher skilled engineering roles. SMEs are concerned that the main cause relates to a basic inability to attract young people into technology related careers; this was identified by 62 per cent of SMEs. This may be linked to the demise of the traditional system of craft apprenticeships (mentioned by 57 per cent of them). Other concerns expressed were that government policy had ignored SET for too long (49%) and that the education system was not geared up so as to provide people with the right skills (46%). There was also the concern that other industries could afford to pay more than manufacturing (42%). All this led to the report’s conclusions that more young people had to be attracted to the engineering profession; also employers felt that this task was best addressed at an early age by way of the education system.

In 2001, 54% of registered engineers had undertaken five or more days of employer sponsored training.

However, it was found that engineering and technology graduates reported the lowest experience of work-related training.

However SMEs themselves could do more to help fill these skill gaps in the future through training more people internally and using the strategy of encouraging continuous professional development (CPD).

Studies of international competitiveness and skill levels demonstrate that the British engineering industry may suffer from a “latent” or “concealed” skills shortage, over and above any skill gaps currently perceived by employers.

8. Engineers in the economy

In December 2001 15 of the FTSE 100 top executives held engineering qualifications,
10 were scientists, and 20 held professional accounting qualifications. This was up-dated again in January 2004 and the situation had changed little as it was found that 12 of the top executives were engineers, 12 were scientists and 20 held professional accountant qualifications.

In 2001, only 38% of professional engineers are employed in manufacturing industry, with another 8.5% in construction. The remaining 54% are spread throughout all other sectors of the economy, including finance and business (where engineering consultancies are found), transport and communications, electricity, gas and water supply, education and health and the public sector.

Data obtained from the DTI using the 2000 Office for National Statistics (ONS) Labour Force Survey count of engineering graduates lends support to the Engineering Council and Engineering and Technology Board Survey figures, as does anecdotal evidence. From financial analysis; to the design and maintenance of dealing desks in the City; to mobile telecommunications; to supermarket electronic point of sale (EPOS) systems, engineering underpins the modern economy. The media, leisure centres and healthcare facilities all depend on professional engineering.

The summer 2001 Labour Force Survey analysed the number of professional engineers (ONS defined) and showed a marginally higher proportion employed in the production industries. 19% were working in finance and business, of which 14% were found in engineering consulting, designing and contracting.

According the ONS Labour Force Survey data the number of persons in employment with a degree in engineering or technology rose from about 437,000 in 1992 to nearly half a million or about 494,000 by 2000. In 2000 this represented 9.2% of all degree holders in employment.

The number employed as professional engineers (ONS definition) has fallen but this has been more than compensated by arise in the number employed as computer analysts and programmers, software engineers and computer engineers.

A significant number of persons holding engineering and technology degrees do not appear to work as professional engineers or scientists. However, this in part relates to their movement into managerial positions.

etb published in 2003 some data as part of a major research programme into the role of technicians, widely defined to include not only engineering technicians but also those working with a science and technology qualification and in the electrical and vehicle trades. The data indicates only 16 per cent of all technicians work in the manufacturing sector but 43% of all science and engineering technicians are found in manufacturing. 26 per cent were found in the public sector as were 24% of all science and engineering technicians and 23% of all IT service delivery occupations. 20% of these technicians were found in the distribution and hotels and catering sector and 71% of the electrical trades were found in this sector. A further 16 per cent of technicians were found in the business services sector and perhaps not surprisingly 39% of draught persons and building inspectors and 39% of IT service delivery occupations were found in this sector.

The main conclusions to be drawn from the research were that the numbers entering these occupations is in persistent decline, while at the same time UK industry is experiencing real problems in both skills shortages and skills gaps at technician level across a wide range of occupational fields. Many begin their careers as apprentices or even graduates but they need to receive further training and career development if they are to keep their skills current and gain further competencies, especially in softer management skills.

Better continuous professional development (CPD) provision would provide a way of unlocking any latent skills already present in the technician workforce.

Another major piece of research was published in 2003 by the Engineering and Technology Board. In September 2002, the Engineering Council (UK) Board invited the Engineering and Technology Board to investigate whether the creation of a new register – tentatively called Chartered or Professional Technologist – would help promote careers in science, engineering and technology (SET).

A wealth of data was assessed for this report and three main approaches were adopted when defining technologists. These were by their occupation, by their qualifications either in terms of level of qualification and more generally by subject of qualification and finally by the sector that they work for. This data is published as an Annex to this publication.

9. Technology, Education and Economic Growth

Over the past millennium, population rose 22-fold and per capita income increased 13-fold. This contrasts sharply with the preceding millennium, when world population grew by only a sixth, and there was no advance in per capita income. Since 1820 world development has been much more dynamic with per capita income rising by more than 8-fold, population by more than 5-fold.

Per capita income is not the only indicator of welfare. Over the long run, there has also been a dramatic increase in life expectancy. In the year 1000, the average infant could expect to live about 24 years. Now the average infant can expect to live 66 years.

But the growth process has been uneven in geographic distribution as well as time. Between the present world leader the United States of America and the poorest region of Africa, the gap in measured living standards could be now as high as 20:1.

Developments in economic theory and research suggest a very important role for technological change and education in the process of economic growth. Few now believe that capital accumulation alone can account for the large increases in standards of living observed in many developed countries today. This theme is further developed in some detail in the body of the text.

More needs to be known quantitatively about the contribution of engineering and science to the UK economy. However the DTI Value Added Scoreboard published for the first time in May 2002 suggested that among the UK's top 500 companies manufacturing contributes 31.6% towards total value added. The oil and gas sector contributed a further 14.7%.

The second Value Added Scoreboard, published in April 2003, found that the four largest sectors in Europe were banks (14.8%), telecommunications (7.8%), automotive (7.4%) and oil and gas (7.0%), while for the UK they were oil and gas (11.8%), banks (10.7%), support services (6.6%) and telecommunications (6.1%). The automotive, electricity and engineering sectors are proportionately larger in Europe than the UK, but oil and gas, food processing, retail and pharmaceuticals are larger in the UK.

In 2003, the Institute of Physics (IoP) published a study that examined the importance of physics to the UK economy. What constitutes a physics based industry (PBI) was arrived at by combining survey work by the IoP and by looking carefully at both the Standard Industrial Classification (SIC) and the Standard Industrial Trade Classification (SITC). The initial starting point was the IoP survey of its members occupations; and members occupations were mapped with precise 3-digit SIC codes used in the compilation of the National Accounts.

The report concluded e.g. that by the year 2000, 43% of manufacturing industry employment in the UK was in PBIs. This represents 1.79 million people. Over the period 1992 to 2000, the number of people employed by PBIs remained more or less the same, while employment in manufacturing as a whole fell by about 10 per cent. Clearly if this is the case, then the importance of physics has increased in significance within manufacturing over this period. The report findings seem to be consistent with the view that manufacturing has been getting more “high tech” over time and that the workforce is becoming more skilled, in response to both supply and demand factors.

UK science and engineering is still world class. In terms of papers and citations per head, the UK is in the leading group along with Canada. Further the UK science and engineering base is responsible for 4.5% of the world’s spending on science, produces 8% of the world’s scientific papers, receives 9% of citations and claims around 10% of internationally recognised science prizes. Also as the Roberts Review noted “Overall, the UK’s supply of science and engineering graduates is strong compared to that in many other industrialised countries, with the UK having more science and engineering graduates as a percentage of 25 – 35 year olds than any other G7 country apart from France”. However, the record for knowledge transfer seems less successful.

In response to the lack of understanding of the precise economic effects of science and technology, research commenced in 2003 with the ultimate aim of quantifying the wealth created by the SET community. To drive this research project, the Engineering and Technology Board (ETB) brought together a working group comprising of the etb, the Engineering and Physical Sciences Research Council, the Royal Academy of Engineering, the Royal Society and the Department of Trade and Industry.

The study quantified the contribution of technological change and SET labour inputs to economic activity; i.e. the contribution of science, engineering and technology to the level of economic activity and to economic growth in the UK and some competitor countries.

One finding of the report is that in 2002, the high SET-intensive sectors of the economy produced £252.3 billion, which was 27.3% of total value added in 2002. Another major finding is that the high SET-intensive sectors contributed towards 27.1% of the total change in labour productivity over the period examined, which was 1993 to 2000; and that the absolute contribution of SET-intensive sectors to UK economic growth was 0.5 percentage points per annum, higher than in Germany and Japan but lower than in the USA and France; science and technology are key drivers of productivity and economic growth.

Other major findings were that the SET community generated more than £77.5 billion of value added in 2002, or 8.4% of the total UK value added; financial services, property and business support was the sector where the amount of GDP generated by the SET community was the highest, ahead of manufacturing; SET professionals generated the highest share of sectoral value added ion the construction sector; and 61% of the value added generated by SET skills was generated outside the SET-intensive sectors.

Finally the report also looked at the contribution of SET-intensive sectors to the economic growth and productivity growth of other developed economies. Here the report found that as the SET-intensive sectors in the UK still account for a smaller fraction of total output growth (i.e. economic growth) and labour productivity growth than in France, Germany (only productivity), Japan and the US, there could be scope for the entire UK economy to grow faster and become more productive by improving the performance of these sectors.

1 Perceptions of engineering and science

We increasingly operate in a global market for goods and services which is driven by technological change and the "knowledge economy" As an advanced developed economy, the UK is underpinned by technology. It is therefore vital that the UK has a strong cadre of professional engineers. The issue of young people's perceptions of engineering as a potential career choice is crucial to the future of the engineering profession, and as such has been the subject of a number of recent studies. The following pages highlight the key findings of some of these. One of the central problems for the image of engineering seems to be the poor availability of useable information about engineering – both as a career, and in broader terms – to young people and those who advise them.

1.1 EMTA/MORI survey

In the recent past the Engineering and Marine Training Authority (now change to SEMTA, the Science, Engineering and Manufacturing Technologies Alliance) commissioned a bi-annual survey of attitudes towards engineering as a career amongst secondary-school age pupils (years 7-11). The survey in 2001 (January - February 2001)[1] found that one in seven pupils would choose a career in engineering, though the majority of these were boys: engineering careers were the preferred choice to one in six boys but only 1% of girls wanted to become engineers, and only 4% felt they might consider this (tables 1.1 and 1.2). This disinterest did not seem to stem from views of engineering as a male-dominated profession (asked if they thought it was 'a job mainly for men,' only a minority of girls agreed, though boys were more inclined to believe so), but might be more closely allied to girls' belief that it was a boring occupation, and one which required work in a dirty environment (table 1.3). Also girls appeared more interested in the law and the caring professions. The figures in brackets are those found available in the 2001 survey but they are not statistically significantly different from those found in the 1998 survey.[2]

Most pupils though do feel that engineering is important to day-to-day life and recognise that it is particularly associated with transport, new technology and computing. Other findings dealt with access to careers and other information about engineering. Parents, teachers and the media were most frequently cited as sources of such information, and visits to engineering companies scored the most points for providing pupils with useful information. Even so, pupils on the whole do not think they know much about engineering.

The survey published in 2001 found that there had been little change in young people's perceptions about engineering since the 1998 survey. The proportion who were considering a career in engineering remained around 15% and predominantly consisted of boys. Ethnic minorities were also more likely to find the sector appealing as a career. A job as a professional engineer was still one of the most popular occupations amongst boys but the appeal of engineering amongst girls continued to be very low. The main obstacles to enhancing the appeal of the sector were that children did not associate it with the factors they found most important in a job, particularly girls. These were principally good pay and salary and doing interesting work. Notably, pupils in single sex schools were more likely to be favourable towards engineering. However, certain more traditional perceptions of engineering continued to decline among young people. The proportion who associated engineering with a dirty environment fell by four percentage points since 1998, but remained over a half at 54%. Engineering was associated with working in factories by a quarter of children, dropping from a third in the 1998 survey. Although there has been no further up-date of this SEMTA commissioned research in January 2004, research was published by Careers Scotland and partners based in or near Edinburgh that sought to analyse factors influencing gender stereotyping of careers and career preferences of young school pupils, aged about 7 to 8 years. Some of the findings of this research[3], although not nation wide as it was based on the perceptions of pupils in Scotland, were consistent with the findings of the recent SEMTA/MORI reports. For example among the jobs found persistently gender stereotyped, were included engineering, plumber and electrician. And few girls felt that they were suited to be an Engineer, only 10% compared to 63% of boys. And with to working in specific economic sectors or industries, many girls stated that they would "not at all" like to work in either Engineering, maintenance and garage work (78%), Construction (73%) and Transport, wholesale and delivery (70%). Pupils' preferences for future jobs appeared to be related to their father's occupational classification (SOC), but not their mother's SOC, with a higher proportion of pupils whose fathers (or step-fathers) worked in "Managerial", "Professional" and "Associate Professional and Technical" wanting to work in "Professional" jobs.

1.2 Tomorrow's World, Today's Reality

In June 2003 the ETB published a report by Bath University which looked at, among other things, the different perceptions of engineering held by teachers and how engineering as a career is viewed and some familiar themes emerged.[4] This study found that Science, Technology and Mathematics (STM) teachers were unclear about how pupils could go on and become engineers, and what qualifications were best suited to this. Both STM and non-STM teachers had positive views on engineers, namely that they are problem-solvers, team players and are financially well-paid. Conversely, they also saw engineering as a dirty, old-fashioned and predominately male career. Also most teachers assumed that engineers would be graduates, rather than entering the profession as technicians or technologists and most teachers were unclear about different engineering sectors. And most were unaware of new developments in engineering, apart from those that related to the school curriculum, which the report felt was a concern.

The teachers generally felt that STM subjects could be taught in a more "engineering friendly" way, but they feel time constrained; nevertheless, they strongly supported the idea that STM teaching should promote the skills, understanding and capabilities which tomorrow's engineers will need. Problem solving, mathematics, practicality and logic were judged to be the most important qualities for an engineer. Although the teachers recognised the importance of engineering, there appeared to be some important missing links: communications between schools and industry are not well-used: links between different subjects within schools are often poor; and teacher's understanding of how their subjects link with careers in engineering are lacking, or need to be up-dated. Finally the study focused on particular factors which teachers felt were blocking the pursuit or promotion of careers in engineering and while there was general agreement that these blockers[5] existed, teachers felt that it was not there job to tackle the issue, since promoting any particular career is not a prime part of their work. The study found that, while everyone could agree on how unblocking steps could take place, or even what these steps should be, it would not be teachers who would be the main agency for these changes.

Also in June 2003 the ETB published another report where the Institute for Employment Studies was commissioned to look at careers guidance literature on science, engineering and technology (SET) and which included mathematics and IT; again some familiar themes emerged and some ways of improving the approach to careers advice and guidance were suggested.[6] This report found that boys and girls consider certain types of jobs to be specific to one gender from an early age, with parental views having a major influence. Also the view that SET occupations are "male" tends to put girls off this area of study, while it attracts boys and girls who also perceive SET occupations as being less to do with people and relationships, something which acts as a further deterrent; these themes have been noticed before and are chronicled above. However, the report also found a new and interesting theme running through current literature on SET career choices, namely the nature of the science and mathematics curricula in England, which are seen as off-putting to children who might otherwise have pursued a SET career. The report suggests that the curricula should be more linked to every day debates and technologies and less based on abstract theories. As for the role of careers advice and guidance the report thought that formal careers advice could have a limited impact and effect due to the influence of parents, friends and the media. However careers advice could be better organised and a more "joined-up" approach to careers guidance where the many and disparate organisations and individuals involved might be better linked, with more student-centred support delivered at the right time for individuals and by an appropriate person. Another area of debate in the report was over the traditional impartiality of careers advisers. Given that early perceptions and subject choices can serve to block whole areas of SET, some argue that careers advice should challenge assumptions and give early guidance, rather than simply alerting young people to what is available. Finally, while the provision of university careers guidance is seen as excellent, there seems to less thorough provision for adults. The Connexions programme may address this problem, with internet-based advice also helping to deliver more accessible, up-to-date and relevant information. Some of the information found there may however be contradictory.

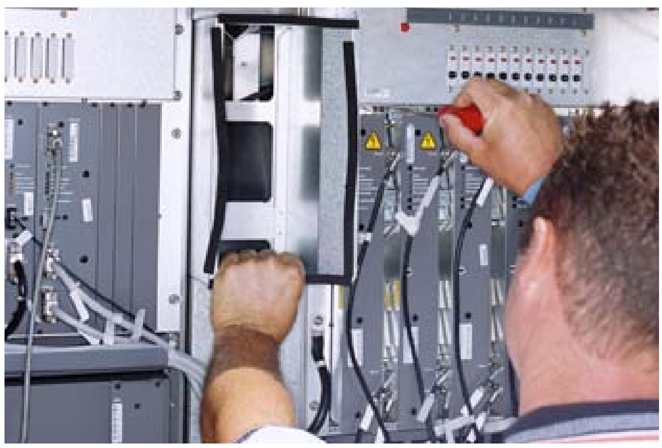
Turning to a more specific area of engineering the Institute of Chemical Engineering has conducted its own research[7] into young people's perceptions of chemical engineering, what influences their career choices and why science apparently turns them off. The research found that students of all ages are motivated by good pay and job security; good working conditions and interesting work are also key criteria for students when choosing a career. Girls in particular are looking for responsibility, interesting work and opportunities to make the best use of their skills, while working with IT and computers is less important to them than to boys.

Finally a careers survey published in 2000 by Roffey Park Management Institute[8] has provided further evidence from young people of the unfashionable nature of engineering as a career. Most of the 1,681 14-year olds who responded to the survey gave a big thumbs-down to finance, commerce, manufacturing and engineering. Instead they largely preferred jobs in art and design or entertainment. A third of respondents specified as their top choice or "dream job" a career in the entertainment and leisure industry. Art and design came second with 8.4% of the nominations. Less than 2% chose engineering as a "dream job".

However engineering did marginally better when respondents were asked to consider a realistic job choice, a "realistic occupation" rather than a career choice that was preferred but not realistically obtainable. The most popular "realistic occupation" was that of designer, including fashion and interior design. The occupation of teacher came second and that of doctor or nurse third. 10% chose a job in entertainment as "realistic" while 8.4% chose art and design. Fewer than 5% gave engineering as a "realistic" choice of occupation.

1.3 Earlier Work on Career Perceptions and Decision Making

Career Perceptions and Decision Making[9] was a 1997 report of a project which looked at the perceptions and knowledge of careers demonstrated by pupils aged ten, fifteen and seventeen at schools in the South East and the West Midlands. Through focus group discussions and questionnaires, it analysed attitudes towards nursing and engineering as careers, with a view to increasing the effectiveness of careers guidance to pupils.



This report found that by age seventeen, 7.2% of the pupils had chosen engineering as a career; only finance, medicine and the arts were chosen by more, and the older children were more likely than younger ones to prefer engineering.[10] The main reason for choosing engineering was that respondents were interested in engineering, and that they had a role model, typically a father, who was already working as an engineer. Role models are therefore a very important influence on the decision to enter into a career in engineering. However, those who had chosen engineering tended not to admit it in group discussions, and a number who had opted for engineering-related occupations (including would-be designers and researchers) did not see themselves as potential engineers.

The principal reason for such behaviour was thought to be engineering's 'negative image,' again largely based on the misconception that it is dirty, manual, intellectually undemanding or even "boring" work. However, along with law and sport, when engineering was chosen as a career it was chosen on the basis of anticipated enjoyment and interest, by over half the people opting for these career areas. The motive of "helping people" does not appear to be a popular reason for choosing a career in engineering (and science excluding medicine), along with other career areas such as law, finance and business. On the other hand no one gave "financial gain" as the main reason for their choice of engineering (and science) or for entering the forces, emergency services and veterinary science. But as noted role models were a particularly important influence amongst those who choose a career in engineering.

There was also a perception that even graduates would have to 'work their way up' from this type of work, and also that sandwich placements involved 'car-mechanic' types of employment. Younger students' perceptions of engineering were biased towards the low skilled manual, vocational training end of the spectrum of jobs within engineering. However, older children and those of middle class parents were more likely to have personal contact with a professional engineer, and hence to know that engineering was a highly-educated, well-paid profession.

Foskett and Hemsley-Brown also drew together the key findings of their report in order to identify a number of general principles and models so as to aid their understanding of the formation of how individuals might formulate plans for the future.[11] Both qualitative and quantitative data provided a wide range of insights into how people and students perceive particular careers and use these perceptions in decision making. Various lessons were drawn from this about engineering and it would seem to be the case that the apparent invisibility of careers in engineering has the effect of creating significant misperceptions about entry levels and routes, and potential career pathways. Potential graduate engineers appeared to believe that they had to enter the labour market at a much lower level than the available evidence suggests. Peer pressure also prevents some more able students from entering engineering because of the perceived low status. It is important therefore to find ways of enhancing the status of engineering among adults and pupils of all ages, not only among those who might consider a maths or science based career. The emphasis on manual work continues to persist and gives the impression that unless students are exceptionally able they will risk entering as a manual worker of some of kind and will have to work them selves up from here. Also young people on the whole had no notion of the entry point for graduate engineering, or the middle range of jobs found in engineering. If they don't believe that they have the exceptional ability to become a space research scientist, for example, then they have little understanding of the jobs that lie between being a space scientist and a car mechanic. And the youngest of pupils are most likely to think that engineering is manual labour and is therefore to be rejected. Unless therefore perceptions of engineering area changed at an earlier age, students are unable to find out that engineering can be of a higher status graduate occupation until they are largely committed to another and different career direction. Students did not appreciate the openings into engineering through graduate routes until they had already embarked on their A-levels; and by then it may be already too late to adjust their perceptions.

1.4 The Engineering Council Survey

In the recent past two questions in the large biennial Engineering Council Survey of Registered Engineers sought registrants' views on engineering as a career for young people. In 2001, over 70% of respondents said they would recommend engineering as a career to a young man, and 66% would recommend it to a young woman (see table 1.5). Interestingly women registrants were significantly more likely than men to recommend engineering to young people of either sex. The principal motivating factors in all cases were the challenge of the job and job satisfaction (table 1.6). However, it is also worrying that nearly 25% of respondents would not recommend engineering at all as a career, and that 'excitement,' 'pay' and 'status' were hardly mentioned as reasons by those who would recommend it. The main reasons registrants took up engineering as a career were because they enjoyed problem solving and were good at mathematics and science (table 1.4).

1.5 Careers Advice

There have been many studies into the effect of careers advice on pupils' choices. Key themes are that individuals appear to be influenced by a variety of "significant others", i.e. parents, siblings, relations, friends, teachers and careers advisers. They are also influenced – as are the "significant others" – by general ideas about the worlds of employment, education, training and occupational change. These depend on the background and environment of individual children. There is limited data on how these "environmental influences" relate to future career choices in specific sectors such as engineering, with the focus of much of the work being on gender role models and the influence of social class and job status of the parents and as Penn has noted a "central element within the sociological literature on these matters in the notion that knowledge, perceptions, beliefs and attitudes towards skills formation are socially structured and now shared equally".[12]

Although formal career guidance tends not to start until secondary school, it is recognised that career-related learning often begins in the primary sector and involves schools working to raise their pupils' aspirations and understanding of society and the world of work.[13] There has been some research relating to younger children, which summarises research into good practice in relation to work-related activities in primary schools.[14] It notes that most "of the factors unconsciously affecting young people's careers choice are in place by the time they are 13 years old". The report sets out guidance and examples of good practice across all curriculum areas: key messages are about the value of activities that contribute to the pupils' understanding of adult and working life, such as visits to workplaces, visits talking to pupils about their jobs and the skills required, project work that allows the pupils to apply knowledge and skills in the workplace and school-based projects that raise awareness of the world of work. Research has also established the importance of parents' attitudes in influencing their children's behaviour and self-perceptions of ability. Results indicated that parents' activities predicted children's self-perceptions in all domains except mathematics (where external factors appeared more influential). Findings also suggest that parents only became more involved in some activities only when they believe that their children need help – so that in fact the areas in which they get involved may well be the child's weakest areas.[15]

Decisions about jobs are made at an early age. By late primary school most pupils have rejected most jobs on the basis of their perceptions. These are highly individual and the product of images of jobs they see for themselves, those passed from parents and friends and those from the media. It is not surprising therefore to find that most 16-year-olds pay relatively little attention to information material on careers, either from school directly or from the Careers' Service, when deciding upon their future after the end of compulsory education. Furthermore, where such materials were used the research indicates that they were not used to influence broad post-16 decisions. Rather young people used them to confirm and reassure themselves about the decisions that they had already made.[16]

1.6 The Public Attitudes to Science, Engineering and Technology Survey

The British Attitudes to Science, Engineering and Technology Survey was a large scale quantitative project funded by the Office for Science and Technology and the Wellcome Trust, undertaken in January 2000.[17] It is therefore possible to assess how the attitudes displayed in this survey compare to some of the findings above and how attitudes may have changed over the last 22 years through comparisons with the findings in the Finniston NOP Omnibus Survey.[18] The latter survey was a two stage stratified random sample for the period 22 June - 5 July 1978. On the question of engineering being a good choice or a good career for young people it would appear that fewer people regard engineering as a good career now than in 1978. However a large part of the difference seems attributable to an increase in "Don't knows". Also there does appear to be a welcome change in attitudes about careers for young females in engineering. Females today regard engineering as nearly as good a career as males and this does not appear to have been the case in 1978 when proportionately far fewer females thought that engineering was good career for a young woman (Table 1.7). However it must be pointed out that in both these cases the Finniston questions were specifically about "engineering" while the OST and Wellcome Trust 2000 questions related to "science and engineering".

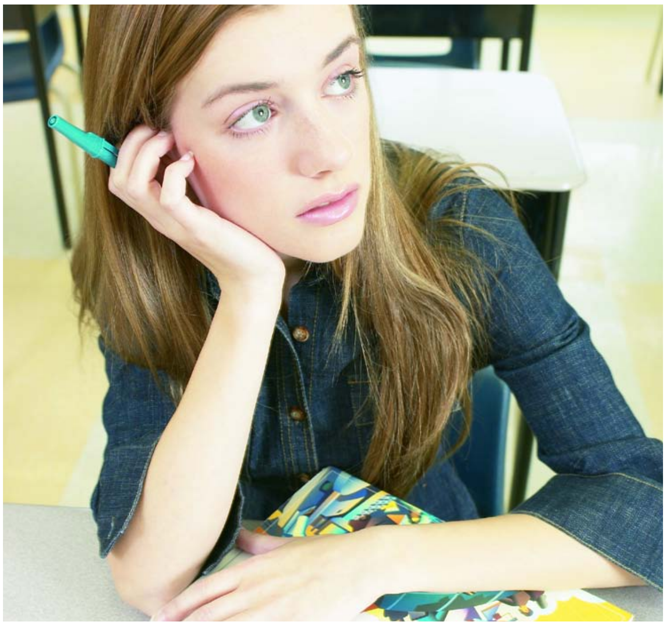
Public impressions and perceptions of professional engineering were very favourable both in 1978, when 68% thought that professional engineers "do a lot to help the economy of this country", and this year when a similar figure (67%) emerged. This was also the response to a differently asked question, when respondents gave reasons people choose to become engineers or scientists. Four out of five people agreed that "Britain needs to develop science and technology in order to enhance its national competitiveness".

When respondents were asked in the 2000 survey for words to describe "engineers" the results indicated very little change from Finniston; engineers were still viewed as intelligent, logical, methodological, rational, responsible, enquiring, but mostly male (table 1.8).

Although the scores for the questions highlighted were broadly similar overall, there was a clear divergence of opinion between the adult group and the younger group in the 2000 survey - the latter being much less positive. The Finniston survey did not provide this breakdown, but the coverage of a similarly representative age range could imply that while adults have become more appreciative of the role of professional engineers, young people are less well-informed than in the 1970's.

1.7 European Attitudes to Science and Technology

Between 10 May and 15 June 2001, an opinion poll was conducted in all the Members States of the European Union. One of the many findings of this report[19] was that the three most highly regarded professions in Europe are those which have a scientific or technical dimension; doctors come first (chosen by 71.1% of respondents), followed by scientists (44.9%) and, thirdly, engineers (29.8%). These findings were mirrored in the United Kingdom where the percentages found were doctors (78.0%), scientists (40.9%) and engineers (36.3%)



2 Secondary education

Chapters 2, 3 and 4 look in some detail at the education, from the earliest age, of potential members of the UK's professional science and engineering base. They deal with the numbers and characteristics of the populations taking secondary-level qualifications which prepare the way for Further and Higher level qualifications in the various engineering, technology and computer-related disciplines.

2. Secondary education

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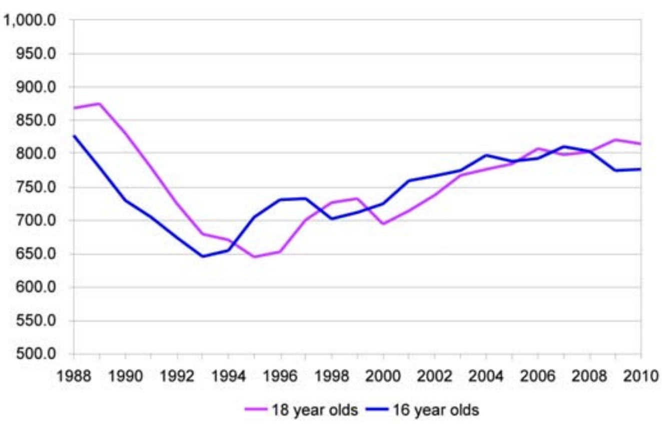
2.1 The cohort: the 16- and 18-year old populations of the UK

Chart 2.1 shows Government population estimates for the numbers of 16 and 18 year olds living in the UK. The period up to the mid-1990s saw a steep decline – of over 20% - in both populations, although some recovery occurred after this. Government estimates suggest that the population remained more-or-less constant in recent years, but small rises are forecast after 2002 with both populations approaching or exceeding 800,000 by 2006. Current population forecasts are now based on the 2001 Census results.

Chart 2.1: 16 and 18 year old population of the UK (1000s) (Source: ONS & Government Actuaries Department Population Estimates, projections 2001 Census)



2.2 GCSE

Charts 2.2 and 2.3 show the GCSE awards made over the eleven-year period to 2003 in Mathematics and Physics (tables 2.1 and 2.2 detail the same information). The mid-1990s onwards have seen just a gentle fall in total GCSE Mathematics awards from 695,409 in 1996 to 684,850 in 2000, but since then the number has risen to 717,097 in 2003 with over a half now marked at grades A, B and C.

In chart 2.3 and table 2.2, the fall of 21,437 Physics awards between 1993 and 1995 (approximately 33%) indicates a trend away from individual Science subjects towards the Science: Double Award GCSEs. Science Double Awards saw an overall 64% increase over the same period (by nearly 400,000), as chart 2.4 and table 2.3 illustrate (but note that the number of candidates is half this). Since 1995, numbers achieving Physics awards have settled at around 45,000 to 48,000. Nearly 89% of candidates achieve a grade C or higher in Physics (with thus only 11% not achieving this), reflecting the relatively high proportion of candidates from independent schools, and the tendency for more able pupils to be put forward for individual Science subjects.

Chart 2.2: GCSEs achieved in Mathematics (all boards, UK candidates) (Source: Joint Council, AQA)

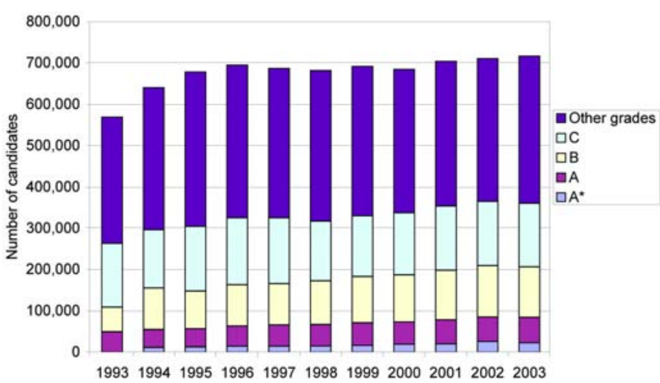


Chart 2.3: GCSEs achieved in Physics (all boards, UK candidates) Source: ONS & Government Actuaries Department Population Estimates, projections 2001 Census

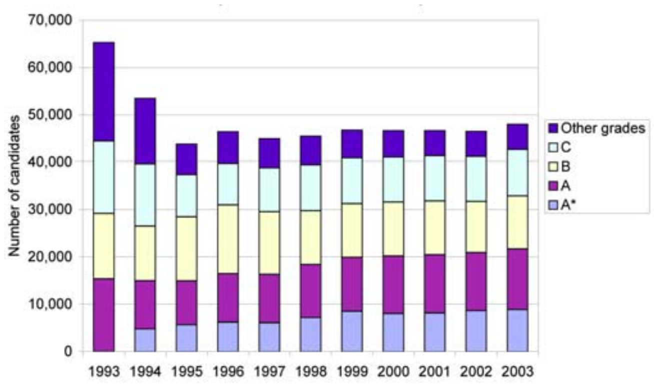
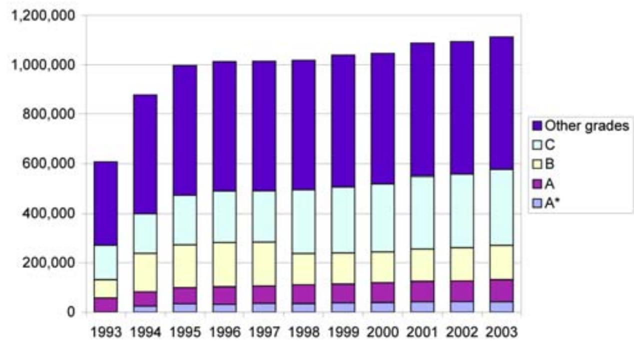


Chart 2.4: GCSEs achieved in Science: Double Award (all boards, UK candidates) Source: Joint Council, AQA



Correspondingly higher proportions of candidates achieve an A* grade (18.5% in 2003).

The figures for the nearly 560,000 candidates achieving Science double awards in 2003 are nearly 54% at grade C or better, with 4.0% at A* (2003) and for nearly 720,000 Mathematics awards the figures are 50.3% and 3.2% respectively. Chart 2.5 and table 2.4 indicate that the number of GCSE awards in Chemistry fell from over 62,000 in 1993 to just below 44,000 in 1995, a drop of nearly 30%, although in recent years there has been a levelling off at around 46 - 48,000 and a rise to 48,876 in 2003. As noticed in the figures for Physics the figures for Chemistry GCSE also suggest a move away from individual science subjects towards Science: Double Award GCSEs. And there is a similar higher proportion to that found in Physics of candidates achieving an A* grade (18.2% in 2003). 89% now achieve a grade C or higher (2002 and 2003). Chart 2.6 and table 2.5 indicate a slowly gathering acceptance and enthusiasm for GCSE in Design and Technology.[20] This subject has been one of the seven subjects[21] in the National Curriculum in England and Wales at Key Stage 4 (14 to 16 years) until 2003. However in the mid-1990's there were two years, 1996 and 1997, when Design and Technology became optional and then mandatory again and this largely explains the drop in Design and Technology GCSE awards from 375,561 in 1995 to 260,759 in 1997. In the last three years the number of Design and Technology GCSE awards has risen by 67% to reach a level of 436,963 in 2001, 428,638 in 2002 and 435,989 in 2003. But there remains a degree of non-compliance occurring at a proportion of schools, estimated by OFSTED to be about 20%. Despite both subjects being compulsory, in 2003, as table 2.1 shows, 717,097 Mathematics GCSE awards were made in the UK and this is just under 65% higher than the number of awards made in Design and Technology (435,989). This difference can partly be explained by the fact that independent schools have proportionately much fewer young people undertaking Design and Technology than do Mathematics. The Independent Schools are not bound by the National Curriculum. However this cannot be the only explanation as the number of pupils at independent schools

Chart 2.5: GCSEs achieved in Chemistry (all boards, UK candidates) Source: Joint Council, AQA

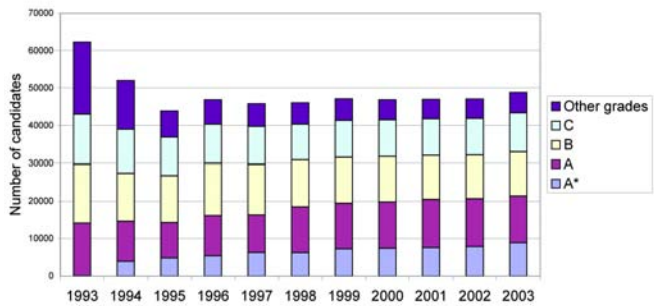


Chart 2.6: GCSEs achieved in Design and Technology (all boards, UK candidates) Source: Joint Council, AQA

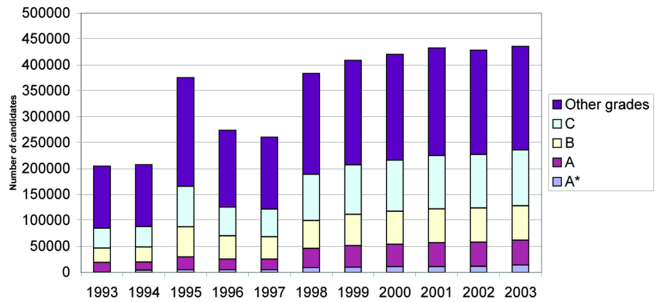


Chart 2.7: GCSEs acheived in Computing and Information Technology (all boards, UK candidates) Source: Joint Council, AQA

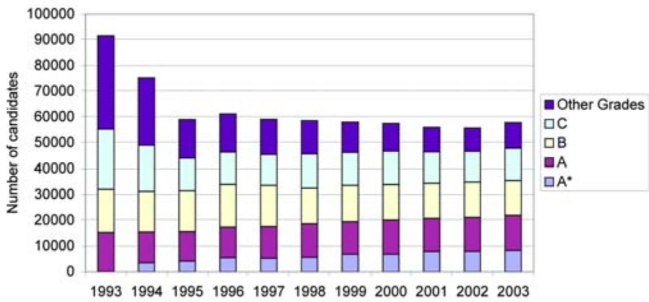
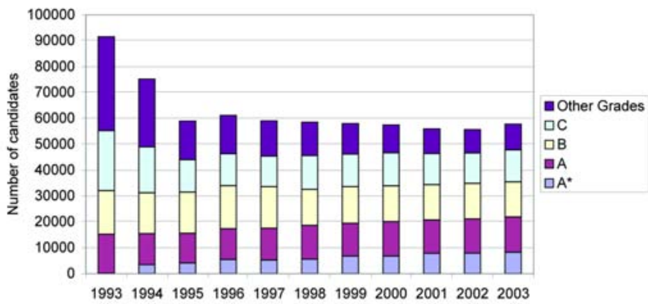


Chart 2.8: GCSEs achieved in Biology (all boards, UK candidates) Source: Joint Council, AQA



is only about 7% of the total school population so non-compliance must be a factor. The number of GCSE awards made in Computing and Information Technology (chart 2.7 and table 2.6) has been expanding rapidly in recent years, rising from 70,566 in 1997 to 117,277 in 2002, an expansion over this period of 66%. Also the percentage achieving A* was 5.2% in 2002, while 59% achieved grade C or higher. However, there was a fall in the 2003 figure to 92,589 but this is partly explained by the rapid increase from 22,734 in 2002 to 45,612 in 2003 in the number of people sitting the GNVQ Intermediate Full Awards in Information Technology. Finally Biology (chart 2.8 and table 2.7) dropped in popularity in the early 1990s falling from 91,559 in 1993 to 59,029 in 1997 and then to the range 55-58,000 during the period 1999 to 2003. The percentage achieving A* was high at 14.2% in 2003, while 82.8% achieved grade C or higher.

Finally, the above general trends of GCSE entrants by subject were perhaps not surprising when seen in the light of figures published in 2003 of the teachers' surveys in 1996 and 2002[22], giving the percentage of schools offering named subjects in year 11 (revised); between the 1996 survey and the 2002 survey the percentage of schools offering combined science fell by 2%, while the proportion of schools offering mathematics, biology, chemistry, physics, other sciences and design and technology remained the same; the proportion of schools offering information and communication technology also remained the same over this same period.

2.3 A-levels

As the subjects often required by Admissions Tutors for Engineering undergraduate degrees, Mathematics and Physics A-level are of particular interest to the engineering profession. Charts 2.9 and 2.11 (and tables 2.8 and 2.10) show the trend in A-levels taken in these two subjects in the UK over the last eleven years. Following a decline in Mathematics A-level awards to 1995 (over 15% between 1990 and 1995), there has been a modest upturn in numbers in the last four years, with 68,502 awarded in 1999 and 65,891 in 2001. There was a fall to 52,657 in 2002 but this was due to problems resulting from the introduction of Curriculum 2000. This was widely seen as a one-off event and the number of people taking AS in 2002 rose by 16.6% from 57,677 in 2001 to 67,268, these figures being both on a provisional basis.[23] The percentage achieving a grade A-E also went up from 71.4% in 2001 to 77.9% in 2002. The changes in the number of candidates taking A-level Mathematics approximates to the curve of the 18-year-old population (see chart 2.9), although the proportion of 18-year-olds obtaining A-level Mathematics awards declined from 10.0% in 1996 to 8.9% in 2001. As expected in 2003 the figure for A-level Mathematics rose, to 54,667, but this figure expressed as a proportion of 18-year-olds was only 7.1%.

Physics, on the other hand, has seen a steeper decline from 37,941 awards in 1993 to 30,768 in 2002 (a fall of 19%) and to 29,730 in 2003. As chart 2.11 shows, this decline was significantly greater than the fall in the 18-year-old population[24] and the proportion of 18-year-olds obtaining Physics A-level awards has fallen slightly from 5.5% in 1991 to 4.1% in 2003. Further Mathematics A-level has traditionally been welcomed by engineering admissions tutors as an indicator of a good grounding in mathematics. Charts 2.9 and 2.10 show the number of A-level awards in Further Mathematics was between 7-9% of the total for Mathematics. The number of awards for A-level Further Mathematics shows rise has since occurred with 5,538 in 1999, 5,362 in 2000, 5,438 in 2001 and 5,337 in 2003; this is probably due to the increase in the use of modules in Further Mathematics.[25] This will help to reduce the need for the

Chart 2.9: A-levels achieved in Mathematics (all boards, UK candidates)
Source: Joint Council, AQA

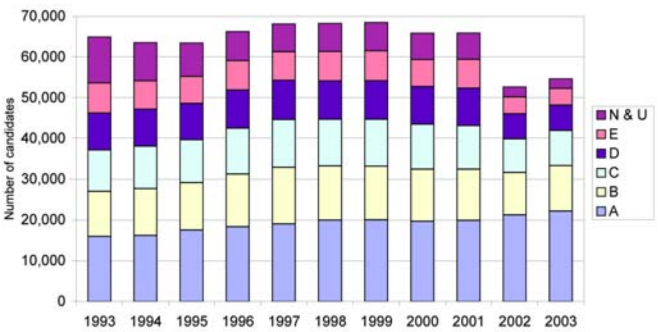


Chart 2.10: A-levels achieved in Further Mathematics (all boards, UK candidates)
Source: Joint Council, AQA

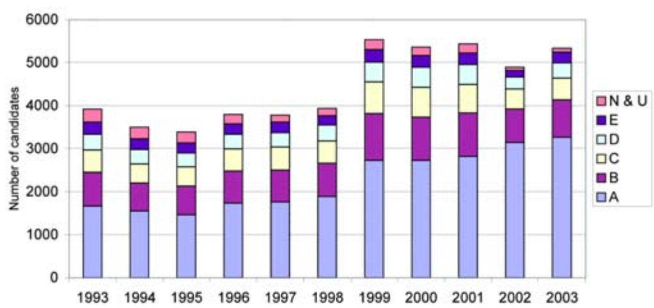


Chart 2.11: A-levels achieved in Physics (all boards, UK candidates)
Source: Joint Council, AQA

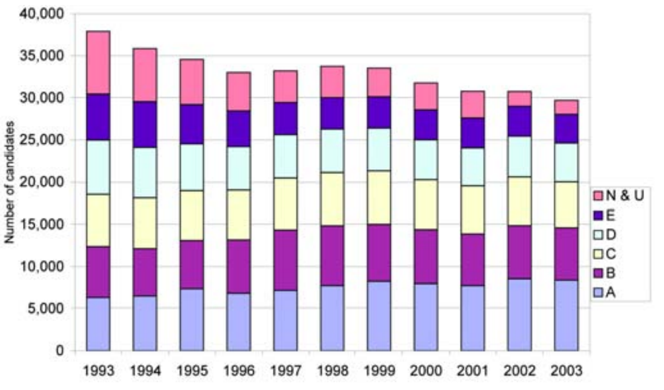
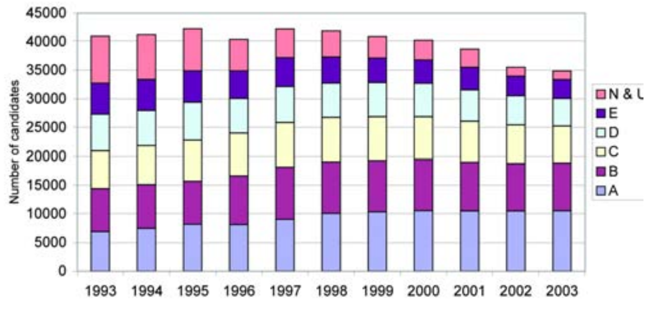


Chart 2.12: A-levels achieved in Chemistry (all boards, UK candidates)
Source: Joint Council, AQA



provision of supplementary mathematics studies for some students studying science and engineering subjects during their first year of University study. Chart 2.12 (and table 2.11) shows that the awards in Chemistry A-level, a subject often required to enter the Chemical Engineering profession, rose from 40,975 in 1993 to 42,293 in 1995 but has since fallen back to 40,261in 2000 and 34,887 in 2003. This was so despite the more or less steady number of women achieving A-level awards in Chemistry over this period (table 2.19). Chart 2.13 (and table 2.12) tracks the increasing number in recent years of A-level awards in Design and Technology, which rose from 10,934 in 1993 to 17,022 in 2003. Chart 2.14 (and table 2.13) both show that the number of A-level awards in Computing rose rapidly from 10,710 to 27,513 in 2003, an increase of 250%. Meanwhile the number of people that sat the National Advanced VCE in Information technology rose from 9,377 in 2002 to 13,468 in 2003, when 47% achieved a grade C or above. However you look at it, computing has turned out to be a popular subject amongst many young people. Finally, the number of A-level awards in Biology (Chart 2.15 and table 2.14) has been steady and in the range 50-55,000 from 1994 to 2003 and in 2003 62% of these were UK women.

If the number of Scottish Higher Grade awards (including both the Higher and New Higher Awards) are included, then the percentages of those in the UK obtaining A-level awards and their Scottish equivalents for Mathematics, Physics and Chemistry expressed as a proportion of the population of 18-year olds, rises to 9.8%, 5.5% and 6.1% respectively (from 7.1%, 4.2% and 4.8) in 2002, the latest year for which data is available from the Scottish Qualification Authority.[26]

GNVQs and the Advanced VCE can also be used to gain entry to Universities and Colleges. In 2001 5.9% of all home applicants (up slightly from 4.8% in 1999) accepted to University engineering and technology courses through the UCAS system gained access using an engineering GNVQ as their main qualification. In the examination of June 2002, 1,514 achieved full awards (up from 1,390 in 1999) out of a total of 2,784 candidates (from 2,866 in 1999) at GNVQ Advanced level in engineering. Also 83 candidates sat the new AS Vocational Certificate of Education in engineering in June 2002 and 61 per cent achieved grades A to E. In 2003 525 candidates sat the National Advanced VCE in engineering compared to 478 in 2003.

The number of accepted applicants at Universities with the A-level combination of Mathematics and Physics has held up in the late 1990's, and reached a level of 20,131 in 1998 (Chart 2.17). There was also been a rise in accepted applicants with the A-level combination of Design and Technology, Mathematics and Physics.

Nevertheless at the turn of the millennium there was been expressed concern about the recent falls in the proportion of 18-year-olds taking A-levels Physics and Mathematics has been expressed by representatives of the electronics industry; and at the same time there was also some evidence for the existence of skills shortages for electrical engineers.[27]

2.4 A-levels and "Grade Inflation"

What might give greater cause for optimism is the proportion of papers achieving grades A, B and C. For Mathematics A-level this has increased from 48% in 1991 to 77% in 2003. For Physics, it rose from 45% to 67% and for Chemistry from 50% to 72% over the same period. But in recent years opinions have been expressed that A-levels have been becoming in general less demanding[28]. Sometimes this criticism has been applied only to non-science A-levels.[29] But more specific evidence that this may have been occurring with A-level Mathematics can be found in an earlier Engineering Council publication "Measuring the Mathematics Problem".[30] This study presents evidence from diagnostic tests of a steady decline over the past decade of fluency in basic mathematical skills and of the level of mathematical preparation of students accepted onto degree courses. Possible reasons given by this study for this apparent decline are changes in syllabuses and structure: greatly reduced numbers taking Mathematics A-level; changes in the teaching force and society; and lack of practice and poor study skills. The change in syllabus that occurred was a brought about by a broadening of the syllabus designed to attract greater numbers of students to Mathematics A-level. This may have meant that some depth in specific

Chart 2.13: A-levels achieved in Design and Technology (all boards, all candidates)
Source: Joint Council, AQA

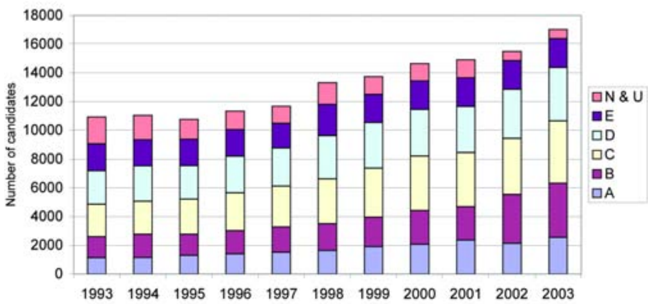


Chart 2.14: A-levels achieved in Computing (all boards, UK candidates)
Source: Joint Council, AQA

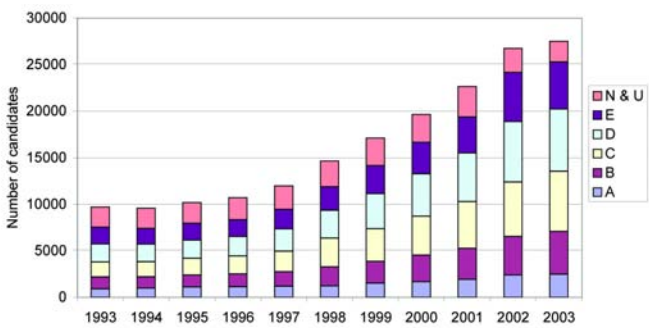


Chart 2.15: A-levels achieved in Biology (all boards, UK candidates)
Source: Joint Council, AQA

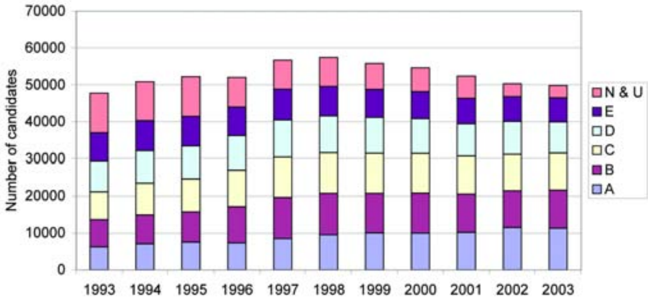
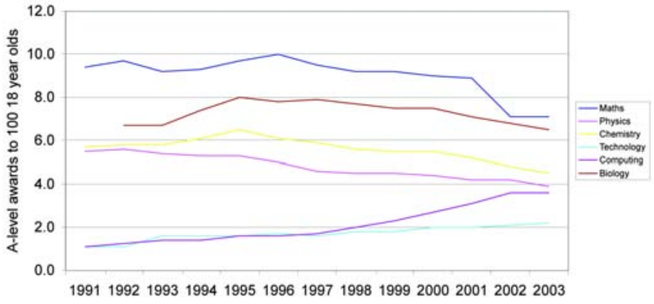


Chart 2.16: Ratio of A-level Mathematics, Physics, Chemistry, Technology, Computing and Biology (Sources: Jount Council, AQA/Government population estimates)



areas, including some of those relevant to engineering, was lost in the process. DfEE data for 1996/97 recorded 20 per cent of Maths teachers as having "no qualifications", this being defined as not having a degree in which Mathematics was the main subject.[31]

2.5 Teacher Supply in Mathematics

Worries over teacher supply in Mathematics are nothing new. In 1977, Parliament was expressing its strong concern over the lack of qualified Mathematics teachers. However the current prognosis also seems gloomy. Higher Education Statistics Agency (HESA) figures reveal that the proportion of those graduating in mathematical sciences as a proportion of all graduates has been falling steeply since the mid-1980's. University Grants Committee figures for 1987 indicate that mathematics degrees amounted to more than 5 per cent of the total degrees awarded that year, while the HESA figures for 1995 to 2002 (table 2.15)[32] show that the current proportion is just 1.7 per cent. Although the absolute number of Mathematics graduates has recently been fairly steady (at the same time as a large expansion in total student numbers), the demand and expanding opportunities for Mathematics graduates in the wider economy have gone hand-in-hand with falling numbers attracted by teaching. If graduate numbers are considered in conjunction with figures for the proportion proceeding to PGCE courses and with DfEE/DfES target figures for Mathematics initial teacher training (ITT), the shortfalls in supply are very evident (table 2.15).[33]

The DfES sets targets for recruitment in each subject in each year and the likelihood of meeting these will depend partly on the numbers of those on undergraduate courses at the present time and also the attractions of teaching. However between 1995 and 2002 the number of Mathematics graduates proceeding to PGCE courses fell by 39 per cent (table 2.15).[34]

A great deal of recruitment is from other sources though, including older entrants and graduates in other, mathematically related disciplines. Also more diverse routes towards qualified teacher status (QTS) are also being developed to make entry easier, notably the provision of school-based training in Mathematics and other subjects, where students are paid as assistant teachers and receive education in school towards the appropriate QTS standards. The consortia of schools that currently provide school-based teacher training are being increased in number.

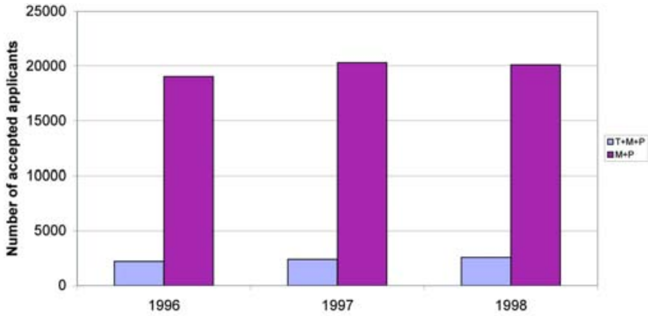
Even so recruitment remains problematic. Actual recruitment for Mathematics for 1998/99, for example, was 48 percent below target.[35] In October 1998 a new style "golden hello" incentive was announced by the DfEE in shortage subjects such as Mathematics, Science, Design and Technology and ICT.[36] This was in the form of a £4,000 grant upon appointment as a newly qualified teacher. This seemed to have a one-off effect in that the Teacher Training Authority (TTA) was able to report that both applications and acceptances were up by over 30 per cent compared with 1998. Nevertheless this left numbers well below target figures and the impact was not sustained. In spring 2000, with Mathematics recruitment targets up, actual recruitment was 20 per cent down on the same period in 1999 (and at a level well below that of 1995). The government responded later in September 2000 by announcing a training salary for all PGCE students, but which is higher for the shortage subjects such as Mathematics.[37] This was in addition to the "golden hellos". It remains to be seen whether the recruitment figures for Mathematics teaching will be improved significantly but it must be hoped that they will.[38] At the end of 2001 there was some evidence emerging that a good start has been made with Mathematics, at any rate with respect to applications.[39] Finally actual recruitment in 2001 turned out to be 80 per cent of target of 1,940 for that year (1,546) in England.[40] But data released in 2003[41] suggested that the proportion of teachers teaching mathematics to year groups 7 – 13 with the highest level of qualification being a mathematics degree remained the same between 1996 and 2002, with this change since 1996 having been calculated taking the 95% confidence intervals into account. And no change in the proportion with a degree in the subject that they taught was also observed in the sciences of biology, chemistry and physics. Also, significant numbers of mathematics and, to a lesser extent, science teacher places remain unfilled – a situation that has remained unchanged since the early 1990's. In 2003 vacancy rates for classroom teachers in secondary schools by subject, January 1997 to January 2002, were published[42] and vacancy rates in 2002 for mathematics (1.9%, Information Technology (2.0%) and Science (1.5%) were higher than those found elsewhere, with average vacancy rate for all subjects being 1.3%. Also the teacher survey data indicated that the proportion of teachers aged 50 or over by subject of highest post A level qualification rose by 7% when the subject was mathematics, after allowance was taken of the calculated 85% confidence intervals; also similar increases, of 5%, were observed over the same period for the subjects of biology and chemistry.[43]

2.6 Women taking A-level Mathematics, Physics, Chemistry, Technology and Computing

Women entrants in 2003 represented 37% of the A-level Mathematics entrants, 23% of those taking Physics, 52% of those taking Chemistry, 37% of Design and Technology entrants, 26.5% of those taking Computing and 62% of those taking Biology. They achieve grades A-C in proportion or in somewhat greater proportion (in 2003 39% of the Mathematics A-C grades, 26.5% of the Physics A-C grades, 53% of the Chemistry A-C grades, 42% of the Design and Technology A-C grades, 28% of the Computing A-C grades and 64% of the Biology A-C grades; similar figures are evident from the 2003 data). Tables 2.17 to 2.22 give further detail about women's achievements in A-level Mathematics, Physics, Chemistry, Design and Technology, Computing and Biology.[44] Based on educational achievement, there is still no reason why women should not make up a similar proportion of Engineering undergraduates. This is regrettably still not the case, as we shall see in later chapters, despite promotional activity by the profession to increase women's participation in Engineering and Science related disciplines.

Another cause of concern is the fact that in 2002 and 2003 although at GCSE level 50% obtaining an award in Mathematics and 40% obtaining a GCSE award in Physics are female, these proportions drop quite sharply to just 37% and 23% respectively at A-level. However for Chemistry 41% of the awards are obtained by females and this proportion rose to about 51.5% at the A-level stage.

Chart 2.17: Accepted applicants at Universities with A-level combinations of T = Technology, M = Mathematics and P = Physics
(Source: UCAS)



3 Post-16 vocational education and training[45]

Until the introduction of local authority maintenance grants for undergraduates in the mid-1960's, study at the local "tech", or technical college, was the principal route for entry into engineering craft and technical occupations, with the City and Guilds/ONC and HNC with endorsements being the academic route for registration. Subsequently during the 1970's and 1980's HNC/HND became the basis for Incorporated Engineer registration, while the introduction of NVQs in the early 1990's replaced most of the City and Guilds courses. Since 1999, the requirement for registration as an Incorporated Engineer is now a degree, or an HNC/HND with a "Matching Section". BTEC National Certificate or Diploma courses and the Advanced Vocational Certificate of Education (formerly GNVQ Advanced) are an important route to meeting the academic requirement for the Engineering Technician registration, which is also achievable through some NVQs.

The search for reliable statistics to chart national progress in further and vocational education and training in engineering has in the past been made difficult by diverse qualification and management arrangements, different forms of accountability, continuing shifts in policy and responsibility, and the very large quantity of raw data.[46] A large number of organisations and agencies collect the data in different ways and there were very few single agencies that presented the information in a comprehensive, coherent, consistent and comprehensible way.[47] The data was often derived from different sources and relates to different cohorts and for different years, with long periods before the final validated data is published and released into the public domain.

3.1 Engineering and construction FE

The Further Education Funding Council (FEFC) surveyed the quality of provision in 1994-95 and 1997-98. In 2000 the FEFC reported that in 1998-99 there were 53,326 full-time and 228,592 part-time engineering students in further education colleges and other institutions funded by the FEFC.[48] These figures were projected to reach 58,094 and 246,045 respectively in 2000-01. These figures included students found in further education colleges that were not funded by the FEFC. These 1998-99 figures represented a fall from the 1995-96 figures of 67,358 full time students and 232,225 part-time students on the engineering programme area. Engineering is widespread in FE and when the FEFC reported in November 2000, they found that in 1998-99 365 out of 423 colleges (86%) in the further education sector had courses in engineering and technology compared with 347 of the 456 colleges (76%) in existence in 1994-95. However, the trend is for the majority of engineering provision to be concentrated in fewer colleges, and in particular in those colleges (representing about a fifth of the sector) which have over 1,000 enrolled engineering students. In 1997-98 the number of colleges with over 1,000 had fallen to 72 compared to 123 at the same time as the survey in 1994-95. At the same time one hundred colleges had fewer than 100 students in 1997-98 compared to 70 in 1994-95. Also in 1997-98 150 FE colleges accounted for 80% of all provision and over 30% of all students are recruited in Greater London and the South East.

Also the significant decrease in students number numbers noted in the above paragraph in the engineering programme area does not imply a major decline on provision as during 1998-99 a number of qualifications were reclassified from engineering to other programme areas, leading to the transfer of over 8,000 enrolments to other programme areas. And the strategic planning information found in this FEFC 2000 report showed a projected increase in student numbers in engineering programme area over the next two years to 2000-01.

The FEFC 2000 report also stated that most colleges with a substantial engineering provision offer a wide range of craft and technician courses in mechanical/ manufacturing engineering, electrical/electronic engineering, motor vehicle engineering, and fabrication and welding. Engineering departments generally offer computer-aided drawing and design and machine tool programming. Short courses are offered in such subjects as hydraulics, pneumatics, logic controllers, and health and safety regulations. Few colleges have courses in other modern manufacturing technologies such as materials requirement planning, manufacturing resource planning or statistical process control. Some colleges offer particular specialisms such as aircraft engineering, nautical engineering, and foundry work which are dependent on close links between the college and the specialist industry. A significant change since the first 1994-95 survey has been the collaborative arrangements that colleges have established with partner organisations to provide courses away from the main college sites. In engineering, the chief partners have been industrial companies and training organisations and the work has focussed on national vocational qualifications (NVQ's), mainly related to Modern Apprenticeships, enabling existing employees to have their work place skills assessed and accredited for a nationally recognised qualification.

In summary the level of provision was found to be wide, although the staple for many colleges has been the NVQ2(F) engineering foundation programme, used by many as the initial off-the-job introduction for new trainees, apprentices, employees etc. Most offer intermediate and advanced courses, and two thirds of engineering FE colleges offer part-time higher education, mostly but by no means exclusively at sub-degree level. This was seen as an area of potential expansion by the 1997 National Committee of Inquiry into Higher Education, and the Government's announcement of the introduction of two-year foundation degrees, has opened the way for this.[49] Foundation degrees are to be largely delivered by Further Education but in consultation with employers and the higher education institutions but they have been slow to be established. In the academic year 2001-02 only 3,775 students were studying for the new foundation degree, all subjects.[50]

3.2 GNVQ and AVCE

Engineering FE has in recent years been subjected to major curriculum change. The Engineering GNVQ was piloted in 1994-95 at Intermediate and Advanced Level. The scheme became fully operational in 1995-96 and continued to grow alongside the existing provision for BTEC First and National Diplomas. As the integrated nature of GNVQ made it almost impossible to provide in a truly part-time mode, it made little impact on BTEC First and National Certificate work. Instead, GNVQ began to establish itself as a route to Engineering HE. However, the initial growth was not sustained, the cumulative effect of a number of different policy reviews. EdExcel-BTEC, the majority awarding body for Engineering GNVQ, saw the popularity of the GNVQ peak and fall; the ratio of 'National' engineering enrolments to GNVQ Advanced Level engineering active candidates settled about 9:1 (see tables 3.1 and 3.2). The part-time GNVQ option enables it to compete with National Certificate for the part-time market and to complement A-levels. The number of Advanced Level GNVQs awarded in engineering rose from 1,390 in 1999 to 1,515 in 2000. However, as the Roberts Report[51] noted in 2002, although the numbers taking GNVQ in science, ICT and engineering have increased in the last few years, "these numbers are small incomparison, for example, to the nearly 40,000 pupils taking A-levels in Chemistry". Also in 2001 the number of Advanced Level GNVQ awards in engineering fell from 1,515 to 1,324 and the number of Advanced VCE awards in engineering were only 213 in 2002 and 408 in 2003 (see table 3.2 and 3.3).

A revised suite of GVNQs became available in 2000. These included part awards, with a smaller number of units being taken in conjunction with A-levels or other qualifications. Further reforms were announced in 2000. In February 2000 the Secretary of State for Education and Employment revealed that the standards of Advanced GVNQs would be strengthened and are now known as vocational Advanced Vocational Certificate of Education (AVCE).[52] The first Advanced VCE awards in engineering, construction, information technology, science and manufacturing were made in 2002 (see tables 3.2, 3.3 and 3.4). In July 2001 the Secretary of State confirmed that new vocational GCSEs will be introduced in 2002 to replace Foundation, Intermediate and Part One GNVQs as the new vocational alternative for 14 to 19 year olds.[53] Vocational GCSEs will be available in subjects including manufacturing, technology and engineering and will enable young people to move on to apprenticeships and into jobs and the first awards were made in 2003.

3.3 NVQ and SVQ

The advent of NVQ and SVQ has had a more significant impact on FE than HE. Many more qualifications have been accredited at levels 1 and 2 than at levels 3 and 4 in engineering and constructing (see table 3.5 and charts 3.3 and 3.4). The latest QCA data shows that by September 2002 a total of 394,783 NVQ/SVQ certificates had been awarded in

Chart 3.1: Total NVQ certificates awarded in Engineering as at 30 June 2002
(Source: QCA, 2003)

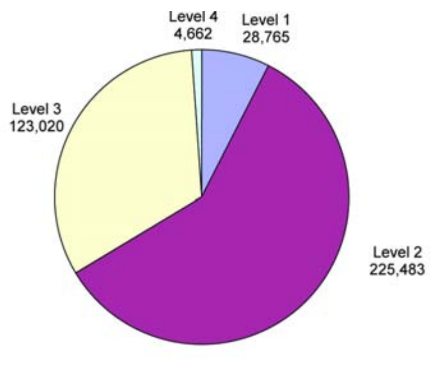


Chart 3.2: Total NVQ certificates awarded in Constructing as at 30 June 2002
(Source: QCA, 2003)

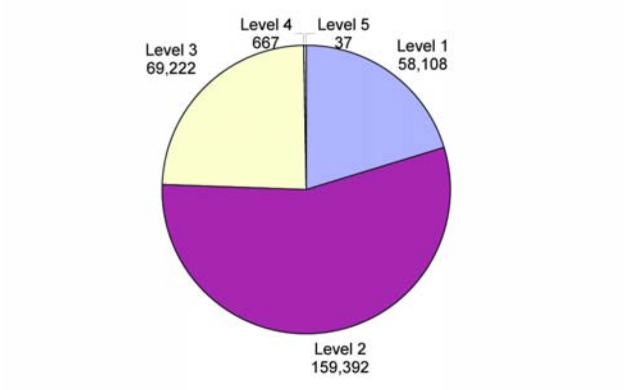


Chart 3.3: Total Number of NVQ/SVQ Awards Each Academic Year - Engineering
(Source: QCA, 2003)

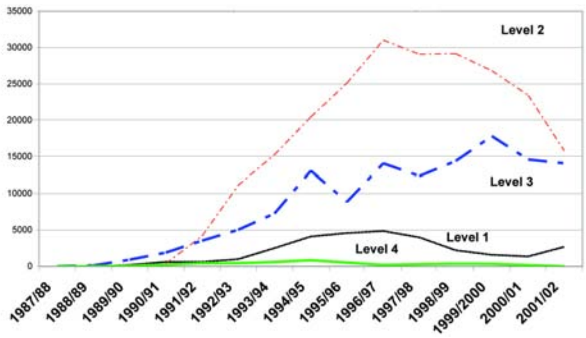
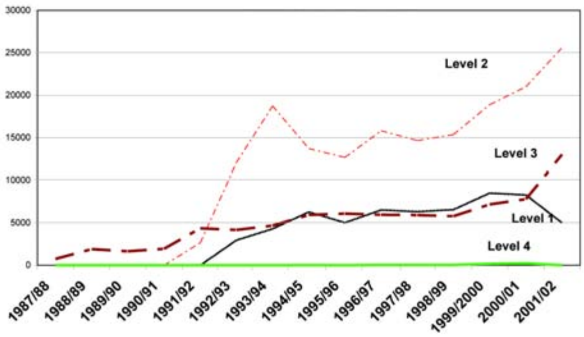


Chart 3.4: Total Number of NVQ, SVQ Awards Each Academic Year - Constructing
(Source: QCA, 2003)



Engineering, with a further 304,526 Constructing (sic), making up 10.2% and 7.9% respectively of all awards.[54] Charts 3.1 and 3.2, together with table 3.5, show the awards in Engineering and Constructing (sic) by level. In Engineering by 2001/2002 66.4% of NVQ/SVQs were awarded at levels 1 and 2. In Constructing (sic) the figure was even higher at 75.8%. However, in recent years there have been signs of a trend decline in the granting of NVQ/SVQ awards setting in, with the amount each academic year falling at most levels in Engineering from the peaks recorded in 1996/97, although this doesn't seem to have happened in Constructing; the reason for this decline appears to be the requirement for a separate demonstration for of key skills such as communication, application of number, information technology, improving own learning and performance and working with others. Employers and trainees unfortunately find a lot of this to be quite irrelevant to the job and as a result of this increasing numbers of potential NVQ holders simply to not complete the NVQ in Engineering.

Moreover, a number of FE programmes, particularly those previously leading to City and Guilds awards, which were a combination of academic and vocational elements, have effectively been replaced by NVQ/SVQ. This has caused some difficulties for FE because of the nature of NVQs as specifications for demonstrating competence without formal guidance on the teaching and learning process. For the majority of people, teaching and learning is a necessary step towards gaining competence. Theoretically, many of the existing and new vocational education programmes should provide much of the lead-up to job competence; this has not always been the case.

The central premise of the NVQ programme is that it is work based and employment led. Employers can undertake their own NVQ training subject to having staff and supervisors who are approved instructors and assessors. This is realistically only an option for larger companies and the majority will use independent education and training contractors. Funding for training which leads to a nationally recognised qualification is now provided through the Learning and Skills Councils (LSCs), and most employers will use this funding through the modern apprenticeship system, although a few may apply direct where they have the infrastructure as described above. There is also plenty of evidence that local industry will provide support for training through donation of equipment to training providers, making their plant and machinery available etc, (confirmed in a 1997 FEFC report). However, this generosity only scratches at the surface of the wider problem across the country of under-resourcing within public sector colleges.

The ability of FE institutions to maintain the engineering base varies widely. As already noted, the tendency is for the best to get stronger, with more than 20% of colleges increasing their engineering student enrolments between 1992 and 1995, when the general trend was for reduction. Recruiting students is, however, only part of the picture. The most significant work on retention rates, which are derived from the number of students who attend their courses to the end compared with the number who started the course, in recent years was that of the Audit Commission and OFSTED in 1993 entitled 'Unfinished Business'. This showed that there is a historically higher non-completion rate for engineering courses, compared with other subjects. The FEFC National Report from the Inspectorate 1999-00[55] noted that the overall retention rate on engineering courses had improved slightly since the previous survey of 1994-95 and was now just below the overall retention rate for all FEFC programmes. However the picture in many departments was mixed. Most had poor retention rates on at least some of their courses with the lowest retention rates mainly on intermediate technician and NVQ level 2 courses. The overall pass rates in engineering remained low: 58% for courses completing in 1997 and 55% for courses completing in 1996. Advanced technician and NVQ level 3 pass rates have been above the average in both years but were still not good. The lower overall pass rates owed much to the poor performance of 16 to 18 year old engineering students on level 1 and level 2 courses. These courses had pass rates which were significantly below the average for all programme areas.

These generally low pass rates were in spite of teaching quality judged to be comparable with other programme areas. The amount of assessment with which students are confronted is often put forward as one of the main reasons for poor pass rates. The amount is especially heavy on craft courses. The need for students to show that they have satisfied the detailed performance criteria for each course has increased the thoroughness of assessment but it has also increased the complexity of the administrative and recording procedures required. Students have to build portfolios of evidence to show how they have achieved the relevant competencies and some of them fail to complete this process by the agreed target date. Nevertheless many engineering departments provided highly successful support in portfolio building to students on company-based NVQs. Another explanation for poor pass rates is that some students only want to achieve particular units of an NVQ course, or similar qualification, and do not offer evidence in support of their other units. These students are likely to be recorded on college management information systems as failing to achieve their qualification even though they may have successfully achieved the units for which they were aiming. However the main underlying reason for poor

performance on many engineering courses is the poor grounding in mathematics during Key Stage 3 demonstrated by the mediocre performance in GCSE Mathematics by potential engineering students. Many students lacked confidence in the manipulation of equations and formulae; mathematical principles were not linked sufficiently to engineering applications.

3.4 Advanced Modern Apprenticeship

Modern Apprenticeships (MAs) were introduced as an initiative in September 1994 and they became fully operational from September 1995. They are funded in England by the DfES, and delivered through the network of Learning and Skills Councils (LSCs). The LSCs themselves work with local and national training providers and employers. The Modern Apprenticeship (MA) was successfully introduced for engineering and should provide the seedcorn for the future at this level.

On 16 February 2000 the Secretary of State for Education and Employment announced measures to reform work based training which included the rebranding of Modern Apprenticeships to Advanced Modern Apprenticeships.[56] The total number of starts for Advanced Modern Apprenticeships (AMAs) in 2001-2002 was 59,300 in England, of which Engineering Manufacturing contributed 10%. The Motor Industry contributed 10% of all AMA starts while Construction contributed 5%.[57] Also in 2000-2001 69 per cent of people on an AMA in Engineering Manufacturing gained a full qualification at Level 3 or above. Corresponding figures for Construction and Motor Industry were 64 per cent and 60 per cent respectively.

However AMA/MAs do have some problems. One is local variations, whereby in the past neighbouring TECs were able to vary their financial support for an identical programme by about 250%; another has been the continuing equivocation over the vocational content or the underpinning knowledge. One problem with work based learning is the relatively low overall 42%[58] success rate for LSC funded work based learning in engineering, technology and manufacturing recorded in 2001/02; success rates include those who either meet all the requirements of their apprenticeship framework or who achieve an NVQ required by the framework. This compares unfavourably with the 56% gaining a level 3 qualification in engineering, technology and manufacturing in LSC funded colleges.[59] The same figures for Construction are 40 and 58% respectively. There are various possible explanations for this disparity. In some cases non-completion may be the result of conscious choices by apprentice and employer. In other cases non-completion will be related to the underpinning knowledge issue and a lack of enthusiasm amongst trainees or employers for the release from work that is necessary for the trainee to obtain the full award. More generally, it may reflect general preferences for academic rather than work-based learning, and a perceived lack of status of NVQs and other problems associated with NVQ/SVQs, as noted above. But as the 2001 report by the Centre for Economic Performance[60] put it "Variability in duration, standards, achievements and funding are such that it is impossible to define apprenticeship in Britain except as 'some combination of paid work and training'. While other factors have contributed, this must be the main reason for the chronic information failure that cripples attempts to promote apprenticeship in the UK – and which has led in the past to apprentices who did not know they were on apprenticeship schemes, and widespread confusion amongst employers".

3.5 Recent Statistical and Inspection Developments

The Learning and Skills Act 2000 gives the Office for Standards in Education (Ofsted) the responsibility for the inspection of colleges in the further education sector and requires that such inspections be carried out jointly with the Adult Learning Inspectorate (ALI). The Act also requires Ofsted to carry out inspections of provision for 16 -19 year olds, with the assistance of the ALI as necessary. Between September 2001 and June 2002, Ofsted and the ALI jointly inspected 73 general further education, tertiary and specialist colleges, 27 sixth form colleges, 12 dance and drama institutions and 11 independent specialist colleges catering for students with learning difficulties and/or disabilities. In the same period Ofsted led 23 area-wide inspections. And in April 2003 the first joint annual report by the inspectorates was published, covering the period from September 2001 to June 2002.[61] The main general findings of this report for the provision of engineering were:

- Failure by too many students to achieve qualifications
- Low attainment in mathematics
- Weaknesses in the monitoring of individual progress
- Low modern apprenticeship completion rates
- Good teaching and learning in many practical lessons
- Frequent high standard of practical work
- Insufficient attention by mangers to improving teaching and learning, or to retention and pass rates

More specific findings were as follows. Regarding the scope of provision of engineering most of the colleges inspected offered a broad range of craft and technical provision. Academic courses leading to GCE A-level and AS-level and AVCE qualifications are provided in both general further education and sixth form colleges. Specialised courses such as marine engineering, lighting and process control are designed to meet local, regional and national needs. Electronic or computer maintenance feature strongly in new course development and assessment in the work place is increasing. Slightly more adults than learners aged 16 to 18, but few women, enrol on engineering courses. Some provision has been developed to suit the needs of pupils aged 14 – 16 who do not attend school regularly. Full-time students often enrol for qualifications additional to their main course of study. In many departments, there are insufficient work experience programmes for full-time students.

And as regards achievement and standards, retention and pass rates differ widely between colleges. They are above 85% on the higher-performing courses. But a minority of colleges run courses where retention rates are typically below 35% and pass rates are below 40%. In practical lessons, students concentrate well on the task in hand, work safety, use tools competently and often produce work of high standard. The quality of students' written work is more variable. In the better examples, assignments are well presented, often making use of IT, and portfolios include a wide range of evidence that is carefully organised. However, some work suffers from poor standards of spelling and grammar. Many engineering students have low levels of mathematical ability. Failure to complete portfolios is a significant factor in the low pass rates on many courses. When it came to looking at students aged 16 to 18, the report found that retention rates in engineering were broadly similar to those of the sector as a whole. But they vary significantly between the different qualification aims. They are lower for two-year courses and for courses leading to NVQs. Pass rates also vary significantly, from 40% to 70%, between the different qualifications. Where craft courses are unit-based, students often have difficulty in completing all the units within the expected timescale. Pass rates for engineering are often below those for the sector as a whole. In nearly all cases the rate is rising, but often at a rate which is not closing the gap. Poor punctuality and attendance are evident in some departments, especially on courses at levels 1 and 2. As for students aged 19 and over retention rates are also broadly similar to those of the sector as a whole. They are lower on two-year courses and NVQ 1 and 2 courses. Pass rates vary from 45% up to 75%. They are highest on courses leading to GNVQ precursors at level 3 and lowest on courses leading to NVQs at levels 1 and 3. They are at or below pass rates for the sector as a whole. And as regards work based learning the proportion of modern apprentices who complete their full apprenticeship framework in the planned time is often low. This is usually because few learners pass the necessary skills qualifications or because arrangements to assess the necessary practical competences in the work place are poorly developed.

And regarding the quality of education and training for students aged 16 to 18 and for adult learners the quality of teaching and learning in engineering is slightly poorer than that for the sector as a whole. Both teaching and learning are better when lessons contain at least some practical work. The teaching of practical skills is often well organised and of good quality. It is at its best where assignment briefs explain clearly what is required and links are made to underpinning theory. The use of realistic working situations or imaginative project work often stimulates students to produce work of high standard. For example, in one college, students produced good work when required to develop specialist motorcycle components. Also the better theory lessons are well structured. These lessons often include a short introduction which captures the students' interest and exposition which is brief and to the point. Links to industrial practice and to students' experience, and the use of demonstration models, serve to improve the interest and understanding. For example, the use of a spinning wheel and a globe to demonstrate the movement of an aircraft stimulated a productive discussion on how the direction of flight is determined. Students' interest, in another lesson, was quickened when the teacher asked students about the welding jobs they were currently undertaking at work. Students' motivation and understanding were often improved by mixing practical work or computer simulation with theory. For example, in one lesson the students were asked to determine the circuit values using calculation then check the answers using computer simulation and then build the circuits and measure circuit values. But much of the teaching of engineering is unfortunately not of the quality described above. Over-long exposition by the teacher, too much note-taking and failure to check that learners are following, often loose the attention of students. This is particularly so where students aged 16 to 18 predominate. Insufficient attention is given to the development and assessment of key skills. Many engineering students possess only the minimum levels of attainment in literacy and numeracy. Full-time students usually have their levels of competence ascertained and additional support is provided where needed. Nevertheless, it was found yet again, that weaknesses in mathematics were thought to be a major contributor to poor pass rates.

As for the quality of education and training for work based learning, work-based learners generally receive good practical tuition when they attend college. Work based learners generally receive good practical tuition when they attend college. Employers are often insufficiently involved in the training programmes, in assessment or in review of learners' progress. Indeed in what appears to be a separate survey of current practice in engineering, technology and manufacturing learning by the Adult Learning Inspectorate, one of the major conclusions was that "Nearly 70% of the wok based learning judged to be good or outstanding is carried out by employers or employers' associations. Most of the best providers identified in the ALI's first Annual Report of the Chief Inspector were employers or employers' group training associations. Many of those were engineering, technology and manufacturing employers and training associations. It is an important feature of this area of learning than many specialist providers are group training organisations (GTOs) representing some 7,000 small and medium-sized employers. There is little outstanding engineering, technology and manufacturing provision in colleges, but that which exists is often associated with strong industrial links. The closer the involvement of employers, the better the education and training".[62]

Finally work-based learners' reviews are often infrequent and, when they do take place, teachers, specialists assessors and workplace supervises are insufficiently involved. Many learners and employers do not understand or accept that key skills certification is part of the framework. Teaching and assessment of key skills often fail to hold learners' interests and are often insufficiently related to the vocational work and workplace experience. Assessment is frequently not planned to ensure that it covers all the requisite NVQ competences. There is too little assessment through direct observation of learners' performance at work. Many staff in the workplace do not understand the NVQ process or the requirement for learners to gather evidence of their acquisition of competence.

3.6 Conclusion

While it is difficult to be sure, with such major changes in types, funding and provision of further education in engineering, it seems that numbers of those taking qualifications leading to course registrations for HNC/HND are slipping. The EdExcel-BTEC registration figures in table 3.1 and the registrations for HND/HNC courses in table 3.6 certainly suggest this. Moreover, many of those taking HNC/HND are encouraged to complete a degree at, or franchised by, a local university. This tends to inflate both HND and degree completions, while disguising the fall in HNC/HND diplomates available to industry.

It must be hoped that the funding arrangements developed by the Learning and Skills Councils will lead not only to a better administration and higher quality of provision of post-16 vocational education, but also to the supply of more reliable and timely statistics. As the 2000 FEFC programme area review report on engineering has stated "There is no reliable data on the scale and nature of training outside the college sector. Without these data it is difficult to analysis and comment on the extent to which the demand for training and the trends in skills needs are being met through the range of training available. The establishment of the Learning and Skills Council should lead to common data and reporting systems, enabling the new Council to complete an annual skills assessment".[63] Indeed, as noted above in Recent Statistical and Inspection Developments, paragraph 3.5, steps have already been taken by the Learning and Skills Council to combine statistical information on both further education and work based learning and information was first presented in March 2003 on learner outcomes in post-16 education and training in England 2002/03[64]; so improvements in data collection have already been made. And finally as also noted above, in September 2003 the Adult learning Inspectorate published a survey of current practice in engineering, technology and manufacturing learning in a wide range of publicly-funded provision.

4 Higher education[65]

The UK has seen an enormous expansion of its higher education system over the last 15 years. In spite of the decline in the 18-year-old population (see chart 2.1), the number of undergraduate course entrants has risen by over one-and-a-half times or 164 per cent over the past 15 years from 119,626 in 1988 to 316,242 in 2003, thereby rising from approximately 14% to 41% of the 18-year-old population (see charts 4.1 and 4.2).[66] The introduction of student tuition fees in 1998 does not seem so far, however, to have put off large numbers of young people entering higher education, according to UCAS.

4.1 Accepted applicants to degree courses

Charts 4.3 and 4.4 show trends in acceptances of home students to undergraduate degree courses in Engineering and Computing subjects[67], differentiated by gender. Numbers of acceptances to Engineering[68] fell over the period 1993 to 2001 but in 2002 at 17,566 and in 2003 at 16,995 there have been signs of a levelling off. However, despite a drop of 27 per cent on acceptances in 1993 (21,335), it could be argued that this was an exceptional year, prompted by the merging of the universities and polytechnics funding agencies with greater funding suddenly available to former polytechnics for engineering programmes. Certainly acceptances to engineering in 1988 to 1990 were of the order of 14,000 to 16,000 per annum. Admissions to Computing subjects[69] have seen a significant rise, increasing over threefold to 20,335 in 2001 over the previous ten years, although the number fell to 18,719 on 2002 entry and 16,998 in 2003 entry. The fall in computer science acceptances was the first annual fall since 1994 and may have occurred because a number of students in 2002 chose to take electronic and electrical engineering instead of computer science; the number taking electronic and electrical engineering rose from 2,670 in 2001 to 5,110 in the 2002 entry. On the other hand, relative to the overall massive expansion in higher education, Computing has increased its market share of all accepted applicants (from 3.7% in 1991 to 5.4% in 2003), while Engineering now attracts only 5.4% of the total cohort (as opposed to 10.7% in 1991) – see chart 4.5. Given the declining numbers taking Physics and Maths A-level in recent years, this is not very surprising.[70] This latter trend might rightly be regarded as a supply factor influencing the number of people joining Engineering courses at universities and colleges. However

Chart 4.1: Total home acceptances to degree courses
(Sources: UCAS/UCCA/PCAS Annual Reports, UCAS Datasets)

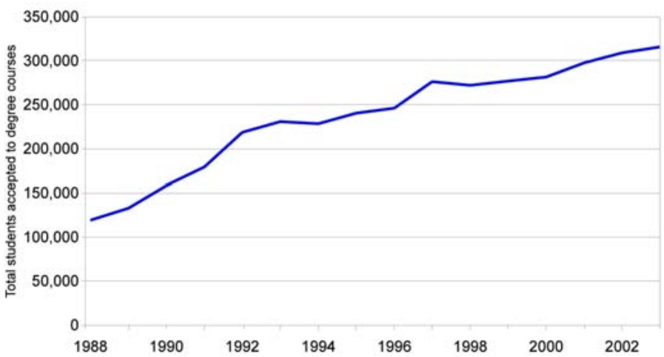


Chart 4.2: Ratio of all home degree entrants to total 18-year-old population
(Sources: ONS Population Estimates; UCAS/UCCA/PCAS Annual Reports, UCAS Datasets)

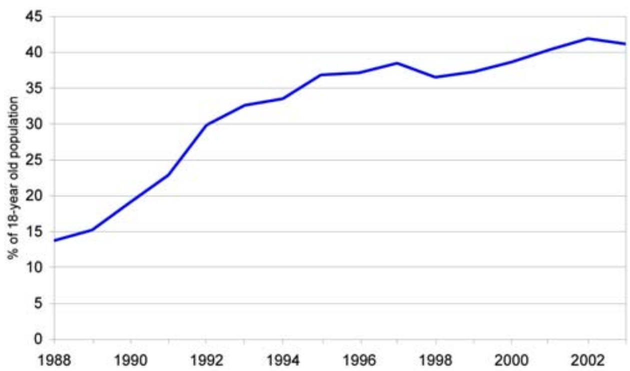


Chart 4.3: Home acceptances to engineering degree courses
(Sources: UCAS/UCCA/PCAS Annual Reports, UCAS Datasets)

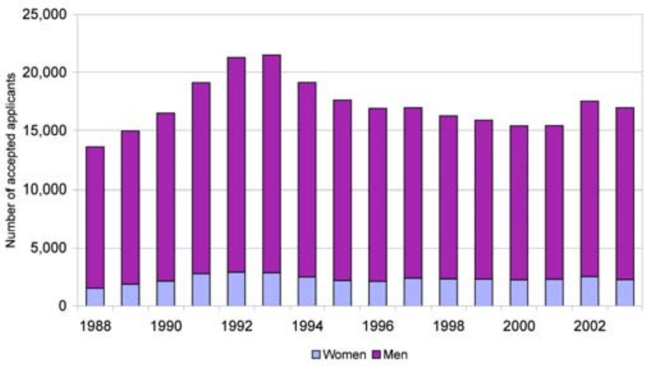


Chart 4.4: Home acceptances to computing degree courses
(Sources: UCAS/UCCA/PCAS Annual Reports, UCAS Datasets)

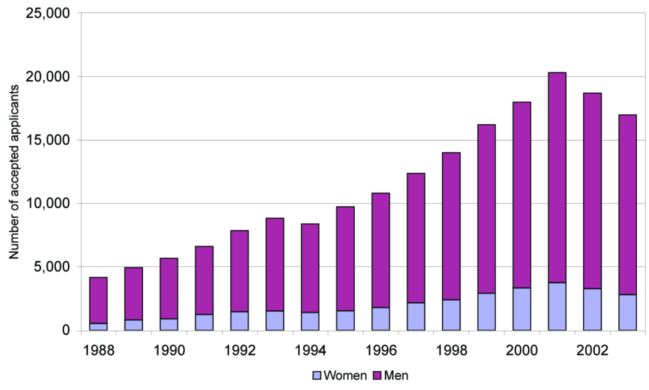


Chart 4.5: Applicants accepted to engineering and computing degree courses as a % of all accepted applicants (home stude
(Sources: UCAS/UCCA/PCAS Annual Reports, UCAS Datasets)

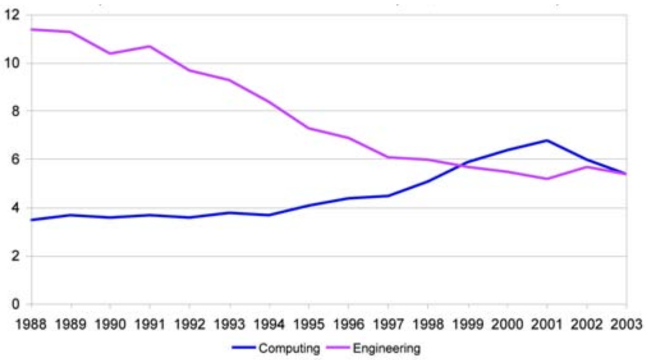
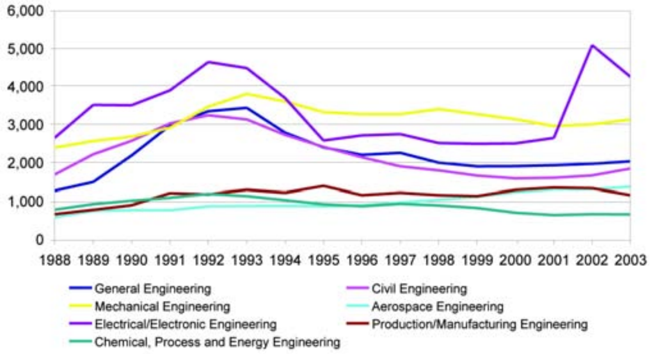


Chart 4.6: Applicants accepted to main engineering disciplines (home students
(Sources: UCAS/UCCA/PCAS Annual Reports, UCAS Datasets)



this does not take into account demand factors that may influence this. One way to gauge the relative strengths of the supply of and demand for Computer Science and Engineering places is to look at the numbers of applications to higher education per place available. This can be done by using UCAS data on the ratio of applicants to those accepted and data for 1998 suggested that the relative demand for both computer science and Engineering was similar, at just over 5 applications per applicant accepted. This compared to an average of 6.2 applications for each person accepted for higher education as a whole. However, later and more recent figures collected under the regime whereby a maximum of 6 applications per student are permitted, the figures were generally less divergent but a difference has been recorded between the subjects of Engineering and Computer Science. For instance in the 2003 entry, Engineering recorded 4.9 applications were acceptance, while in Computer Science it was 5.3; these figures compare to 5.4 applications per acceptance for all subjects.

But as a quite recent study has pointed out[71], UCAS data may be too limited. Data obtained e.g. from Heap's "Degree Course Offers"[72], has data obtained from admission tutors and thus includes students who do not apply through UCAS. This source seemed to indicate greater demand for Computer Science courses than Engineering courses, with nearly 8 applicants for every computer science place, compared to just under 6 applicants for every Engineering place.

However if HESA figures are taken for the total cohort of people taking a first degree 2001/02, then the figures become 6.7% for Computer Science (from 6.8% for 2001 entry via UCAS but using a more inclusive definition) and 7.8% (of the total cohort) for Engineering (from 5.2% via UCAS for 2001 entry). The higher HESA percentage figure for Engineering is probably due mainly to the fact that proportionately more students move onto a first degree after completing an HND course in Engineering than do graduates in general. Students who continue to study at the same university after completing their HND in Engineering will be picked up in the HESA data but not by UCAS.[73]

4.2 Individual Engineering disciplines

Table 4.1 shows the numbers of students accepted through UCAS and its predecessors, to Engineering, Technology and Computing degree courses by discipline over the period 1988 to 2003. Chart 4.6 shows detail of those Engineering disciplines that attract the largest numbers of students. Interestingly, while some subjects show a rise-fall pattern similar to that for total Engineering and Technology acceptances (Civil, General and Mechanical Engineering), others seem relatively unaffected by this pattern (Aerospace, Electrical & Electronic, and Production/ Manufacturing Engineering).

4.3 Women studying Engineering and Computing

Overall, women constituted only 13.4% of applicants accepted to Engineering degree courses in 2003, and this proportion has remained between 13 and 14.5 per cent since 1991 (see chart 4.3). Computing as a subject area has achieved growth in total numbers, and even greater popularity with women students. The proportion of Computing degree entrants who were women increased from 13.1% to 18.6% over the period 1988 to 2001 (see chart 4.4), but this proportion has since fallen to 17.5% in 2002 and 16.5% in 2003.

Chart 4.7 and table 4.2 show the number of women applicants accepted in the most popular engineering-related disciplines in 2003. More women entered Computing courses than any other technical discipline – 2,814 women accepted places on Computing courses (constituting 16.5% of a total of 16,998 acceptances). Electrical/Electronic Engineering attracted the next largest number of women (419 or 9.8%), followed by General Engineering (268 or 13.0%). Chart 4.8 and table 4.3 show the same information, but as percentages, showing the relative popularity of Chemical Engineering with women students (women made up 23.2% of Chemical Engineers, a higher percentage even than Computing). However, even in subjects where women are moderately well-represented, this proportion still falls short of their representation in related subjects at A-level (see above, paragraph 2.6).

4.4 Men and women studying science and technology

Chart 4.9 and Table 4.5 contain data about home acceptances to the main science and engineering course from 1994 to 2003. Biological Sciences acceptances increased from 13,916 in 1994 to 20,463 in 2003 an increase of 47 per cent; this excludes Sports Science which was classified as biological science for the first time in 2002; this accounted for 6,196 acceptances in 2002 and 6,716 in 2003. If this subject is included as a Biological Science, then the growth between 1994 and 2003 increases from 47 per cent to 95 per cent or nearly double.[74] The other main discipline that has recorded an increase over this period is

Chart 4.7: Home acceptances to technical degree courses by discipline, 2003
(Source: UCAS 2003 Entry Datasets)

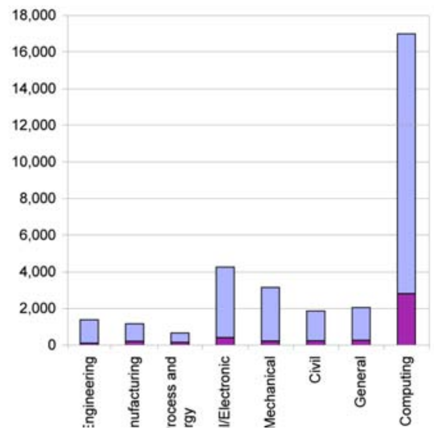
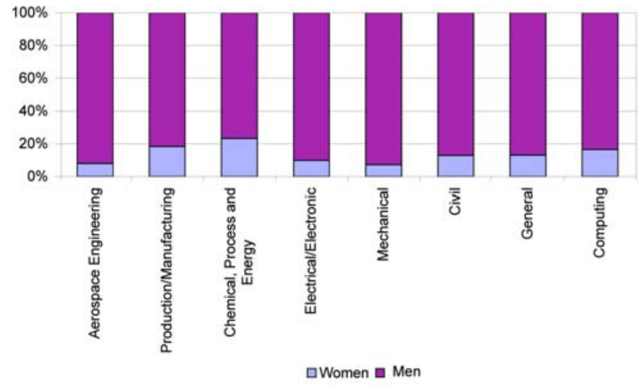


Chart 4.8: Percentage of each gender by discipline, 2003
(Source: UCAS 2003 Entry Datsets)



Computer science. Although, as noted above the number of computer science acceptances has declined in the last two years of entry, the number rose from 8,401 in 1994 to 16,998 in 2003 entry, a growth of 102 per cent or just over double that recorded in 1994. The other main disciplines have recorded declines over the same period. Mathematical and Physical Science acceptances declined slightly by 3 per cent from 17,778 in 1994 to 17,261 in 2003. Engineering and Technology, however, fell from 19,156 in 1994 to 16,995 in 2003, a fall of 13 per cent. However, 1994 represented a change from the average over recent previous years and it could be argued that 1993 and 1994 were exceptional years, prompted by the merging of the universities and polytechnics funding agencies with greater funding suddenly available to former polytechnics for engineering programmes.

Chart 4.10 and Table 4.6 show that the gender proportion of the main science, engineering
and technology disciplines differs a great deal. The biological sciences seem to appeal to females as 71% of acceptances in 2003 were female when sports science is excluded; the proportion that is female falls to 65% when Sports Science is included. However the proportion that is female of the acceptances to the Mathematical and Physical Sciences in 2003 was 40%, while it was much lower than this in Computer Science, at 17%, and Engineering and Technology, at 13%, in the 2003 entry.

4.5 Drop out rate or Non-continuation rate

In December 1999 for the first time a common set of performance indicators in higher education was published for all 175 publicly funded higher education (HE) institutions in the United Kingdom.[75] The purpose of these HE indicators is to provide better and more reliable information on the nature and performance of the UK HE sector as a whole; to influence policy decisions; and to contribute to the public accountability of HE. Also use of these indicators was intended to enable HE institutions and funding councils to identify good practice and disseminate it throughout the sector.

Much attention was focused on the indicators revealing how many students who entered higher education finally achieved a qualification and by deduction (at any rate for all HE students) how many do not - the non-continuation rate or the so-called "drop-out rate". For a range of subjects figures for what is termed "non-continuation following year of entry" can be found in table form for young full time first degree entrants. For those who entered in the year 1996-97[76] for Engineering the non-continuation rate of 12% was higher than any of the other subject groupings listed. The corresponding figures for both 1997-98 and 1998-99 were °11% (compared to 8% for all subjects and 7% for biological and physical sciences) and figures for 1999/2000 were little changed with 10% for engineering compared to 8% for all subjects and 7% for biological and physical sciences.[77] The major factor in all the above years in pushing this figure upwards was the high rate of "non-continuation" found amongst those students with low A-level entrant scores and those with entry qualifications classified as "none" (26%), "others" (28%) and "GNVQ3+" (20%) in 1998-99. This seems to suggest that if better A-level entry and other entry requirements were met, then a significantly better performance could be expected to be achieved by the Engineering Departments found in the HE institutions. Similar

Chart 4.9: Applicants accepted to the main science and engineering courses (home applicants) (Source: UCAS Annual Reports and Datasets)

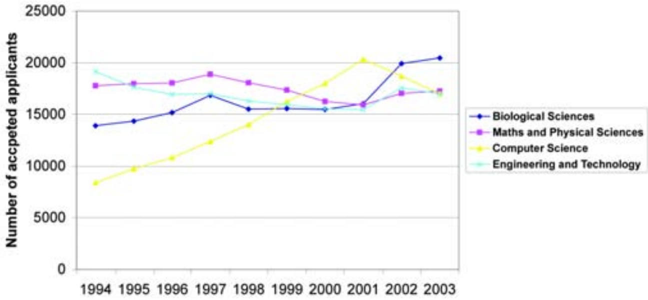


Chart 4.10: Percentage of each gender by main science and engineering discipline (Source: UCAS 2003 Entry Datasets)

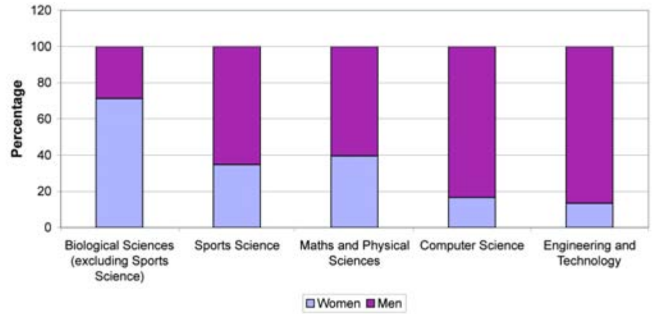
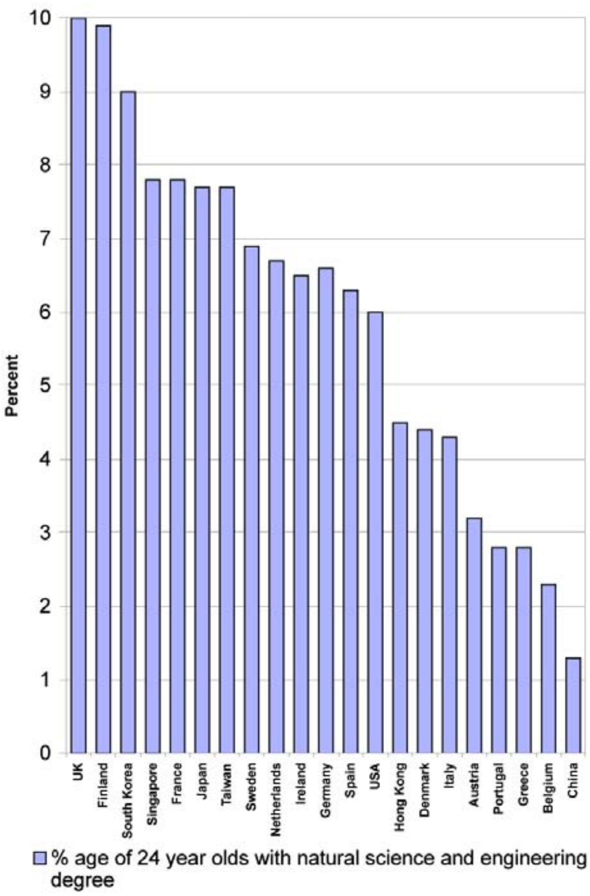


Chart 4.11: Percentage of 24 year olds with engineering and science degrees by country, 1999 (or most recent year) (Source: National Science Foundation)



figures were found in the latest December 2003 edition of performance indicators, although the non-continuation rate for engineering and technology had fallen to 9% for young entrants to full-time degree courses, 2000-01; however, this compared to 7% for all subjects, 6% for the biological and physical sciences and 8% for the mathematical and computing sciences.[78] Non-continuation rates in engineering and technology are highest for the main entry qualification of GNVQ level at 18%, BTEC/ONC at 15% and the entry qualification "none" of 19%, although these non-continuation rates are now not that much higher than those recorded for all subjects at 14%, 14% and 16% respectively.

However what is probably more worrying for Engineering is that HESA figures suggest, at least tentatively, that the "non-continuation rate" over the longer run, and after a period of three years, may be as high as 37% compared to a figure at the same time of 18% for all students.[79] The HESA based figure[80] is obtained by extracting for 1997/98 the total number of first year undergraduates in Engineering of 29,727 full time and 2,320 part time (or a total "input" of 32,047) and for 2001/02 the total number of first degrees awarded of 18,425 full time and 1,860 part time (or a total "output" of 20,285) and subtracting the "output" figure of 20,285 from the "input" of 32,047. This figure while interesting is not an entirely accurate measure of what is sought, since, for instance some full time Engineering courses last for three years and some for four years. However a fall of full time and part-time students from 32,047 of those coming in to study Engineering to 20,285 four years later of those leaving with an Engineering degree (i.e. a fall of 37%), should perhaps be causing some concern. But it must also be borne in mind that this HESA data includes not only UK domiciled students but EU and non-EU foreign students, and it is not therefore consistent with the HEFC performance indicator data as the latter deals with home applicants accepted to engineering and technology degree courses after a period of 12 months.

4.6 International comparisons of Engineering graduate populations

In order for the UK to compete in products and services requiring technical innovation, it is crucial that we continue to produce high quality engineers and scientists in sufficient quantity to supply the needs of industry. This is one of the key factors that led to the strengthening of standards in the Engineering Council's SARTOR 3rd Edition and which was carried through in the UK Standard for Professional Engineering Competence (UK-SPEC) published at the end of 2003.[81] An attempt to analyse the relative quality of different countries' technical workforces would be a difficult or even impossible task, although it is often suggested within the engineering profession that, by age 30 or so, there is little to choose between graduate Engineers from different countries, irrespective of national educational background.

On the other hand, quantitative data are easier to determine, though the nature of international statistical data collection, particularly the time it takes to gather it all in and analyse it, means that data cannot be as recent as national information. Charts 4.11, 4.12 and 4.13 are based on data published by the American National Science Foundation[82]. These charts show the relative position of the UK in terms of numbers of graduate engineers (and scientists) in 1999 (or most recent year) and expressed as a percentage of 24 year olds and of all first degrees awarded.[83]

Chart 4.12: Engineering and science as a % of all first degrees by country, 1999 or most recent year (Source: National Science Foundation, USA)

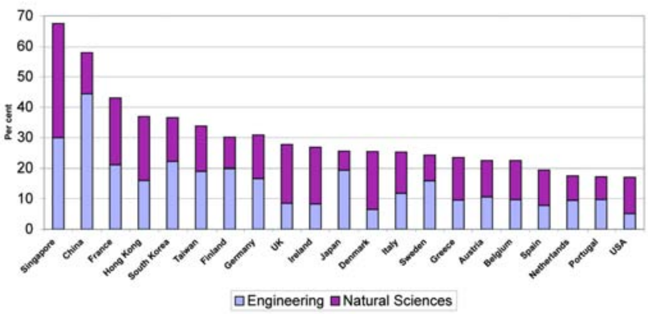
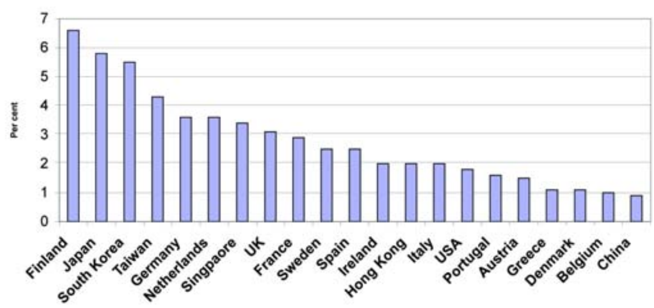


Chart 4.13: Percenatge of 24 year olds with engineering degrees (Source: National Science Foundation, USA)



China and Japan produce vastly greater numbers of Engineering graduates than other countries (199,354 and 103,440 respectively). But it is perhaps worth noting here that the European Union produces in total 134,692 engineering graduates. However the USA is unusual in producing a significantly larger number of Natural Science than Engineering graduates. This is also the case in the UK. And numerically, the UK educates more graduates in all subjects than any other country in the EU,[84] and more Engineering graduates than any other except Germany (which produced 32,663 in 1999 compared to 22,012 in the UK in the same year). Also when the number of Engineering and Natural Science graduates is expressed as a proportion of 24 year olds (chart 4.11), China falls to the bottom of the league (the 21st), the UK comes first and the USA thirteenth.

As a proportion of all degrees awarded in 1999 (or most recent year), however, (chart 4.12) quite a few competitor countries surpassed the UK for Engineering. In 1988 Engineering still accounted for as much as 11.4% of UK degree entrant – falling to 5.4% of degree entrants in 2003 – see section 4.1 above. By contrast, 44% of first degrees awarded in China, and (within the EU) more than 16% of first degrees in Germany, Finland and France, were in Engineering.[85] But although in Germany nearly 17% of first degrees awarded in 1999 were in Engineering, there has also been a fall in the popularity of Engineering degrees. The total number of enrolled Engineering students at university rose from just under 40,000 in 1980 to 80,000 in 1992 but has since fallen to about 45,000 in 1997. The number of enrolments for mechanical and electrical engineering has fallen particularly sharply from over 28,000 in 1990 to about 13,000 in 1996. The output of engineering graduates in Germany has therefore also fallen in recent years but it has been projected that the output of engineering graduates will stabilise in 2004.[86]

Engineering made up only 5% of all first degrees awarded in the USA, however. Also the American Engineering Workforce Commission has reported that the numbers of bachelors' degrees awarded reached a 19 year low of 62,500 in 1999, with engineering graduate awards having peaked at 77,572 in 1985. However in the Winter 2001 issue of "Engineers" the Commission reported that that the number of bachelors' degrees awarded has risen to 65,195; this increase continued the growth that began in 2000. And later on the Commission reported an increase to 68,648 in 2002. Moreover, first year enrolments in engineering jumped by 15 per cent between 1999 and 2001, suggesting that the number of engineering degrees awarded is likely to rise in the next few years. In looking at the distribution of degrees among technical fields, civil engineering has decreased significantly - down an average of 6.5% per year since 1997. Computer engineering is growing most rapidly, and could have had the largest number of degrees in 2002.[87]

As in the UK in recent years, the movement towards a mass higher education system seems to have resulted in Engineering attracting a relatively low proportion of the total student population – even though the actual number of Engineering graduates may have risen for a while (see above, section 4.1). At the time of this review the National Science Foundation data published in 2002 found that 35% of young Americans, 38% of young Dutch, 33% of young Finns and 32% of young Spaniards held a first degree. The corresponding figure for the UK in 1999 was 36%.

When the number of Engineering graduates is expressed as a percentage of 24 year olds (chart 4.13), the position in the UK relative to other countries looks quite favourable in resource terms. Finland heads the list at nearly 7%, with the UK seventh at 3%, the USA fourteenth at 2% and China last (21st) at 0.9%.

However some care in interpreting the above statistics may be needed as we may not be comparing like with like. Higher education systems may appear different due to the differing lengths found for engineering courses in various countries. But on closer examination, a pattern of a kind emerges, based on the concept of a binary approach: a short cycle of 2 - 4 years study which leads to a degree or sub-degree qualification and a long cycle based on 4 - 7 years study leading to what is claimed to be the equivalent of a masters degree. The short cycle equates to some kind of technologist qualification (Incorporated Engineer in the UK) and the long cycle to a Diploma Engineer (Chartered Engineer in UK terms).[88]

Even those countries that, on paper, have a single-cycle pattern do in practice tend towards the 2-cycle approach: the United States, for example, which has a sizeable proportion of masters degrees in engineering (25% of total degrees awarded). Traditionally, the UK has based the basic engineering education on the 3-year bachelor degree but UK-SPEC 2003 moves engineering education firmly towards a 2-cycle system.

A continuing feature of engineering education in European countries is the discrepancy between the nominal and actual length of degree courses. For example most Italian engineering degrees are nominally 5 years in length but actually take 6 - 8 on average. This has lead to some disquiet amongst the authorities in a number of countries who are concerned that in today's world someone entering employment at 26 or 27 with relatively little work experience may be at a disadvantage compared to a younger graduate who has a year or two's experience of life in the real world under his belt. Germany, in particular, has set up a pattern of BSc and MSc degrees to meet this problem. How far it will compete with the long-standing and prestigious Diploma course remains to be seen.

4.7 Enrolment of Foreign Students in UK Universities

In the UK, as the Roberts Review[89] noted, the greatest proportion of PhD students from outside the UK is found on engineering courses. Typically 40 per cent to 50 per cent of engineering PhD students in the UK are not of UK origin. This level of participation by non-nationals is not exclusive to the UK; in 1995, 40 per cent of all US science and engineering doctorates were gained by citizens of foreign countries, up from 27 per cent ten years previously. Also 56 per cent of engineering doctorates awarded in 1991 - 1995 were gained by non-US nationals.[90]

There is also an increasing proportion of non-UK citizens enrolled on undergraduate courses in engineering. In 1995 this proportion was 14.1 per cent but by 1999 it had risen to 20.8 per cent. By far the largest proportions in 1999 by country of origin were Greece (5.3%) and Malaysia (3.3%); see table 4.10 for further details.[91]

5 Graduate employment

The rapid expansion in higher education (HE) during the last decade, together with a shift to a more open and diverse HE system has created a wide range of choice for potential students. It has also posed challenges to universities and colleges in their marketing and recruitment. Students are increasingly seen as customers with individual needs and preferences and there is consequently a competitive market for HE with more emphasis put by the higher educational institutes on marketing. Choice of a higher education institution to enhance future employment prospects is becoming a more important factor these days in applicants' minds, particularly as the perception of student debt increases.

When graduates leave HE, the labour market environment and their resulting financial position is less favourable today than it was some 10 or 20 years ago. Student loans were introduced in the academic year 1991/92 and tuition fees were introduced for the academic year 1998/99.[92] Student debt levels continue to rise and were projected to reach an average of £12,000 for all graduates and £14,000 for engineering graduates by 2002[93], from 2000 levels of £6,507 and £7,695 respectively, for those students in debt. As a result graduates' first jobs are more likely to be temporary, part-time or of a "non-graduate" nature than they were, as graduates are pressurised more to take any employment they can find which brings in some income. However, a later graduate survey from Barclays Bank[94] found that student debt levels averaged £11,000 in 2002 and were therefore below the expected £12,000. This was up 17 per cent on 2001; a large majority of students are in debt with only 12 per cent of graduates leaving university completely debt free, a decrease of 3 per cent on 2001. Students continue to be practical when it comes to borrowing money with the vast majority (96 per cent) choosing the cheapest source, the Student Loan Company. 81 per cent of total graduate debt is now owned to the Student Loan Company, with the average owned now £9,192.

As a consequence of this outcome in the short term, a number of labour market institutes have undertaken longer-term studies looking at the employment experience of graduates for periods of up to 11 years. They are, of course, designed to find out and assess where graduates end up in the labour market in the longer term and when graduates are likely to have better paid, more permanent and "graduate" jobs. And they usually give information about salaries, type of employment, employment patterns and career paths.

5.1 Student Debt and Engineering

The breakdown of student debts in deciles amongst engineering and all graduates demonstrates that engineers owe more than the average graduate does across the debt spectrum. Thus engineers can expect to have higher debts after graduation. This may have implications for the demand for engineering courses as elder brothers and sisters who have involvement of higher debts feedback this experience to future students. It is of particular concern to postgraduate study. Unless graduates can see a clear reward for postgraduate engineering study, the higher debts in the future could result in a disincentive for further study. Evidence has emerged in recent years that it is proving harder to encourage UK graduates to undertake a PhD in engineering (or science), when it is clear that they can earn significantly more in private sector companies who are also seeking their skills.[95] The Roberts Review report came to the same conclusion too namely "that PhD study is financially unattractive in the short term. The gap between PhD stipends and the starting salaries of able graduates has increased dramatically over the last 25-30 years and more recently this is exacerbated by increasing levels of undergraduate debt".[96] Thus it can be anticipated that the effect of the student funding system changes being made may have a more severe effect on engineering than in other disciplines.

5.2 Annual surveys: First Destinations of Students Leaving Higher Education Institutions

The Higher Education Statistics Agency (HESA) conducts an annual survey of those students who graduated during the previous year. The First Destinations survey[97] provides information on whether or not new graduates enter employment during their first six months or so in the market, and what kind of jobs they get if they do.

Chart 5.1 shows the breakdown of initial first destinations (6 months after graduation) of all 2002 graduates; of Engineering graduates; and of Computer Science graduates. The most striking feature for the 2001 graduates was the proportion of Computer Science graduates entering full-time employment, at 63%. Engineers were not far behind at 62%. Overall only 56% of all students were in full-time employment. Part-time employment was correspondingly less common for engineers and computer scientists (at 3 to 5%) than for the graduate population as a whole (6%). However the economic slowdown and the recession in manufacturing experienced in 2002 meant that the proportion of 2002 engineering graduates entering full-time employment was down to 58%; and all graduates and computer science graduates were the same at 55%.

However, in 2002 as in 2001, about the same number of engineers and fewer computer scientists immediately undertook further postgraduate training courses: 10.8% and 8.4% respectively, as opposed to 9.3% of all graduates. However, the evidence in the longer term is that 31% of engineering graduates end up participating in a master's course within three years of graduation, the highest proportion of any other discipline except natural sciences

Chart 5.1: First Destinations of UK Domiciled Graduates 2001/2002
All graduates

Source: Figures derived from: HESA reference volume First Destinations of Students Leaving. Higher Education 2001/2002

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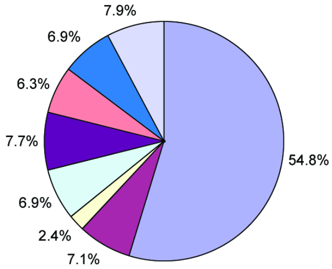
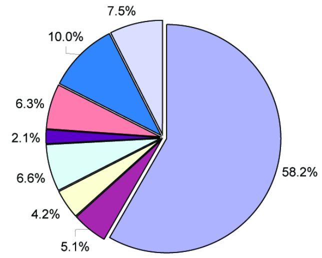
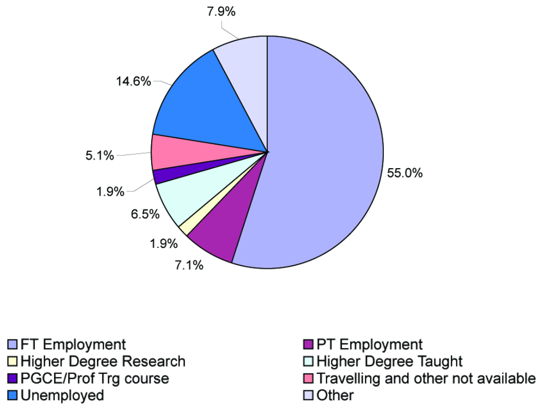
HESA cannot accept responsibility for any inferences or conclusions derived from the data by third parties.



Engineering graduates



Computer science graduates



(33%).[98] Analysis of those in employment by Standard Industrial Classification (SIC) of their employer, indicates that at the end of 2002, 10.9% of all employed graduates went into the education sector, but only 3% of Engineering and 7% of Computer Science graduates did so. In particular regrettably, but nonetheless inevitably for a profession in demand, very few Engineering graduates go on to become school teachers (only 0.4% of Engineering Council registered engineers gave 'school education' as their field of work in both the Engineering Council Surveys of 2001 and 2002; only 0.3% gave this in the Engineering and Technology Board 2003 Survey of Registered Engineers). At the end of 2002, 25% of engineering graduates in employment entered manufacturing, compared to 9% of computer science graduates and, 8% of all graduates.

Those graduates who had entered employment by December 2002 are analysed by Standard Occupational Classification (SOC)[99] in chart 5.2 for all graduates, for engineers and for computer scientists.

The most striking feature of chart 5.2 was the large proportion of Engineering graduates employed in professional positions – 45% but down from the 51% found a year earlier, reflecting the recession that occurred in manufacturing during 2002. This compares though to the 25% proportion of the total graduate population. Conversely, only 9% of Engineering graduates held secretarial/clerical jobs, as opposed to nearly 18 % of all graduates. Engineering graduates were less likely than average to be working as managers/administrators (12.7% versus 16%). This suggests that graduate engineers are more likely to start their careers as technical specialists, and only move into management later in their careers.

Computer Science graduates, on the other hand, had a greater tendency to be employed as associate professionals.[100] 35% of those in employment fell into this category, although as many of these occupations are IT occupations then many of these occupations have been reclassified as professional occupations under the SOC 2000. A further 17% had professional occupations, as defined by the 1990 SOC. They, too, were relatively less likely than average to be involved in secretarial/clerical work.

5.3 Annual surveys: Graduate Salaries and Vacancies 2002 and 2003 - AGR

The Association of Graduate Recruiters (AGR) conducts an annual survey of graduate salaries and vacancies among its member companies (mostly large, 'traditional graduate employer' companies with formal graduate training schemes).[101] This gives comparative data for the starting salaries offered to graduates from different disciplines, and also the employers' views on recruitment and skills issues.

Table 5.1 shows the reported salaries for graduates starting work after graduating in 2002. The overall median starting salary was £20,300 in 2003 (a 4.1% increase on the 2002 figure, and in line with the 4.3% rise in average earnings in the year to March 2003). The median starting salary for graduates working in engineering and IT or software was near the average, at £19,400 and £20,000 respectively. Table 5.2 puts this information into historical perspective: it shows the median starting salaries for some key functions from 1995 to 1999, with scientists/engineers and IT/computing staff consistently achieving above near or above average starting salaries during this period.

Table 5.3 shows median starting salaries by business function or career area. For IT, salaries are near the overall median at £20,000 per annum, while median salaries in civil engineering were £19,500 and in mechanical and electrical engineering they were £18,900 per annum. Highest salaries were found in investment banking, £35,000, solicitor or barrister, £28,000 and accountancy and actuarial work at £24,000.

The other key aspect of graduate recruitment covered by the AGR survey was that of vacancies. Table 5.4 gives details of the number of vacancies overall in 2002 and in 2003. While quite large increases in vacancies were recorded in transport and logistics (17.5%) and smaller increases in energy and water (6.5%), large declines were registered in investment banking or fund management (-34.8%). Overall the total number of vacancies fell by 3.4% in 2003 to 11,012.

5.4 Annual surveys: The Graduate Experience 2002 Report – DTI/Barclays

This report gives detailed results of a survey undertaken on behalf of Barclays Bank and the Department of Trade and Industry, of 2,446 graduates six months after leaving university (between 22nd November and 16th December 2002).[102] The principal focus of the study was the group of degree holders which had studied subjects of particular relevance to the Information, Electronics and Communication (ITEC) industries[103]. The primary objective of the survey was to compare the experience of this group with the experience of their peers. Within this group two subsets were also identified for the purposes of detailed comparison: engineers and computer scientists. The subsets were defined using the definitions adopted by HESA.

Key findings included the following:

60% of all graduates were in permanent employment 6 months after graduation, a decrease of 5% from the previous year; this suggested that graduates in general were further affected by the economic slowdown in 2002. 59% of engineers were in permanent employment and while this is in line with the whole sample it is 16% down on a year ago. Computer scientists (63% of them) were slightly more likely to be in permanent employment than other graduates and this was about the same as last year (62%). Also 24% of engineers were in short term employment, up from 14% in 2001 and just 9% in 2000 (see table 5.5). And unemployment amongst engineers was 17% in 2002, up from 11% in 2001 and 9% in 200. Engineers therefore have been more affected by the economic slowdown than most other graduates; proportionately more of them work in manufacturing, where an economic downturn rather than a slowdown in the economic growth rate has been experienced.

42% of all graduates in the sample were in the job of their preferred career (compared to 50% in 2001 and 47% in 2000), with the lower figure in 2002 reflecting the overall economic slowdown. But graduates in the two subsets were more likely to be in their chosen career. 49% of engineers were in a job of their preferred career and this was consistent with previous years. And 57% of computer scientists were in a job of their preferred career and this was up from 53% in 2001.

35% of all graduates were in a graduate job in 2002, although 43% were in a graduate job in 2001. Engineers were more likely to be in a graduate job than other graduates in 2002 (43%) but this proportion decreased by 20% between 2001 and 2002, again highlighting the affect of the economy on engineering and manufacturing. 34% of computer scientists were in a graduate job, consistent with previous years.

The public sector was the most common area of employment (38%) for graduates in general (up from 33% in the previous year), but engineers were more likely to be in manufacturing (45%), although this was down from 54% in the previous year due to the economic recession in manufacturing. Consultancy was the most common destination for computer scientists, with 37% working in this sector, but this was down form 45% in 2001 (table 5.6).

The subsets' favourable position in the job market was reflected in their salaries: engineers and computer scientists were earning 29% and 14% respectively above the typical graduate salary of £14,000 (table 5.7). Top-earning engineers' salaries were comparable with top salaries for all graduates, suggesting that the overall higher-than-average earnings were not caused by a small number of exceptionally well-paid people. In fact, the variation seemed to be near the bottom end of the pay range, where engineers and electrical engineers were paid 25 - 40% more than average (table 5.8). 51% of engineers earned a high salary, defined as £18,000 or more, compared to 21% of the whole samples of graduates.

43% of all engineering graduates had completed an accredited course in the 2002 survey. Engineers with an accredited degree earned an average £17,735 and this compared with an average £18,125 among non-accredited engineers. This lower figure for accredited engineers may have been affected by the age profile of the two groups and it could be expected that mature graduates would on average earn more than younger graduates in the early years (table 5.7). Non-accredited engineers are older than accredited engineers; they are also more likely to have vocational entry qualifications.

Chart 5.2: Employment of UK Domiciled Graduates 2001/2002 by SOC
All graduates
Source: Figures derived from: HESA reference volume First Destinations of Students Leaving. Higher Education 2001/2002
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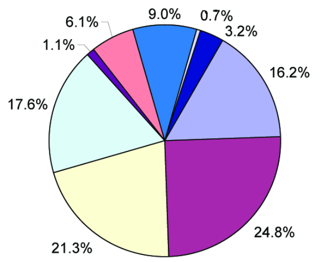
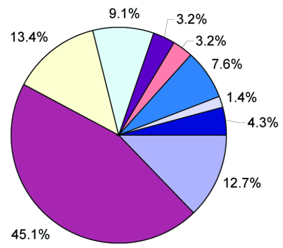


Engineering graduates



Computer science graduates

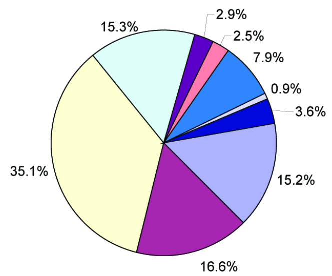
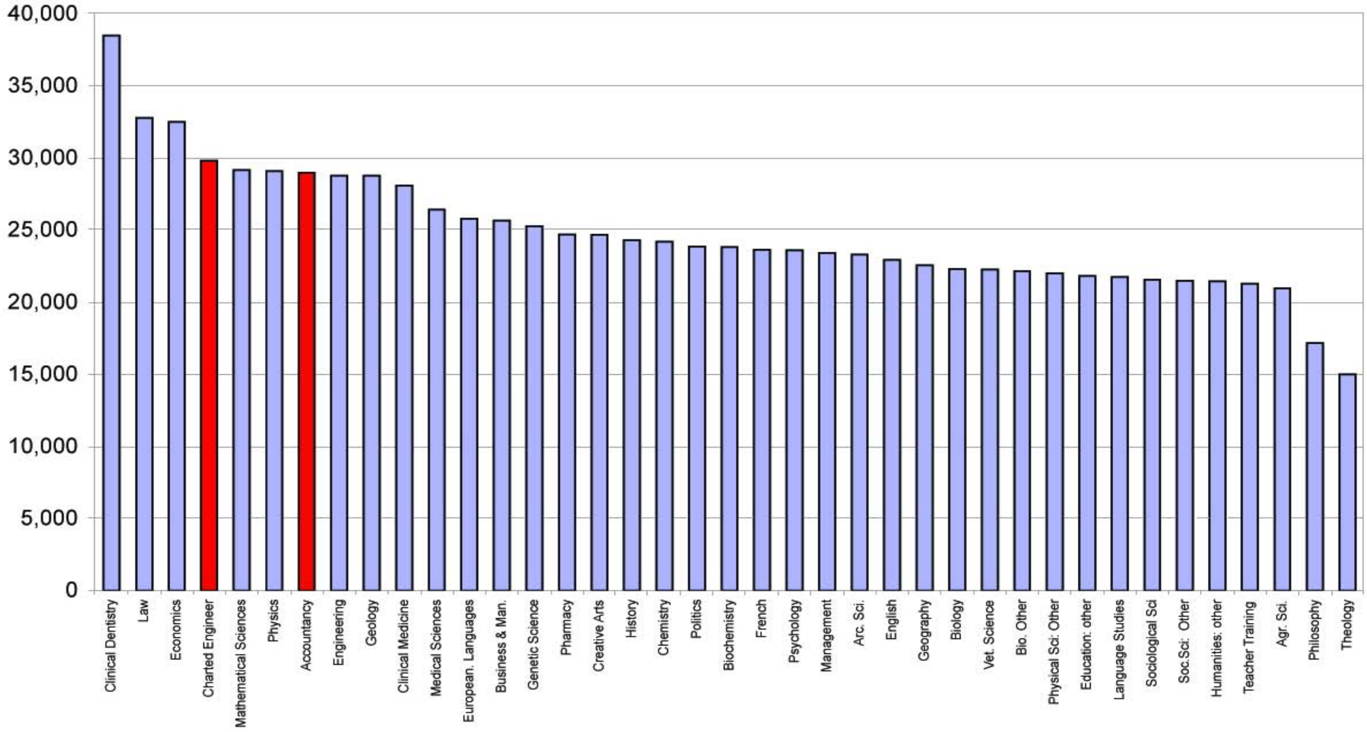


Chart 5.3: 1996 Salaries of 1985 graduates by degree subject
(Source: HEFCE, Mapping the Careers of Highly Qualified Workers, Dearing 1997, and Engineering Council for Chartered Engineer, age up to 34 years)



As to perhaps be expected, graduates who obtained a higher class of degree earned a higher salary than those who obtained a lower class degree (table 5.9). But those with a first class degree in engineering, electrical engineering and computer science earned respectively 12%, 27.5% and 18% more than graduates in general (table 5.9).

Graduates expected to earn, on average, £25,000 in five years time. This expectation was consistent with the previous year. Graduates who achieved a first class degree, that were in a graduate job or training scheme and that had received sponsorship whilst at university had higher salary expectations. Engineers' salary expectations were 20% higher than graduates from the whole sample; engineers expected to earn a median salary of £30,000 in 5 years time. Computer scientists expected to earn more than whole sample graduates, but their expectations were not quite as high as engineers as, on average, they expected to earn £28,000 in 5 years time.

5.5 Longitudinal studies: What do Graduates Really Do? And What do Graduates do Next?

The Institute for Employment Studies at the University of Sussex has, in recent years, played a significant role in the long term studies described at the head of this chapter. What do Graduates Really Do? (1996)[104] followed the fortunes of whole cohorts of graduates of the University of Sussex through their early years in the job market. What do Graduates do Next? (1997)[105] brought the narrative up to date. The two volumes together give a comprehensive account of the careers of 1991, 1992 and 1993 graduates over the four- to six- year period (depending on cohort) since graduation.

Employment: six months after graduation, Applied Science graduates (including engineers and computer scientists) were more likely to be in permanent employment than graduates of any other discipline (42%), and after 18 months this had risen to 64% (see table 5.10). According to the 1997 survey, 97% of the Engineering graduates were in employment (still the highest rate for any discipline, though this was based on a relatively small sample) – see table 5.11.

Occupation: by late 1994 (between 18 and 42 months after graduation according to cohort), 75% of Engineering/Technology graduates were employed in professional occupations, a success rate rivalled only by social scientists (see table 5.12). Only 4% of engineers were employed as managers/administrators at this point. Relatively few engineers or computer scientists were employed in clerical/secretarial roles (compared with 23% of Humanities graduates). By 1997, (four to six years after graduation) there seems to have been some movement amongst engineers towards management roles, with 53% in professional occupations and 27% in management/administration (table 5.13).

Salaries: throughout both studies, Mathematical Science graduates (mainly computer scientists) achieved the highest salaries of all graduates, followed closely by Engineering graduates. By 1997, 38% of graduates from all three cohorts were earning in excess of £20,000 (a significant improvement on the 7% in the earlier study). 64% of mathematical scientists and 57% of engineers were in this top earnings band.

5.6 Longitudinal studies: Moving On

As noted above more and more young people are choosing to extend their schooling well beyond the compulsory requirement. Also over the years past there has arisen a greater desire for education programmes to meet the skills needs of the labour market. Higher education is now a considerable and increasing investment by government. So it was therefore not surprising that the DfEE and the Higher Education Career Services Unit (CSU) came together in 1999 to finance a major study of the early paths of a cohort of graduates (and diplomates) who qualified in 1995. The result of this study, the "Moving On"[106] report published in November 1999, was also highly relevant and timely in view of the publication for the first time in January 2000 of a set of performance indicators[107], including "employability", for higher education institutions. In the "Moving On" report information was obtained from 11,125 ex-students (a response rate of 27%).

Graduate "employability" was the first factor to be examined. And dimensions of this such as unemployment and employment in a non-graduate job were examined. A key finding here was that a survey conducted about 12 to 18 months after graduation was likely to provide a good predictor of the likelihood of future employment difficulties and good measures of the job quality for those who were in work. And three and a half years after graduation only 2% of economically active graduates were unemployed and less than 10% of graduates were in a non-graduate occupation. Most moved into work with relative ease and found work in traditional graduate or graduate track occupations.[108] However it should perhaps be pointed out here that over the period examined by the "Moving On" report, the UK economy was achieving record levels of employment and the lowest levels of unemployment seen for about 20 years.

Employment in a non-graduate occupation was found to be associated with particular degree subjects. Graduates with degrees in mathematics and computing, medicine and related, education and engineering had much lower odds of being employed in a non-graduate occupation. And earnings three and a half years after graduation were correlated to gender, age, prior qualifications, degree class and subject.

Regarding earnings: engineering graduates after three and a half years earned, on average, nearly £22,000 per annum. This was 16% more than that obtained, on average, by all graduates of £19,000 per annum. Graduates who were unemployed 6 months after graduation typically earned 16% less than their peers did by the end of the three and a half-year period. 62% of the engineering graduates stated that they earned a "good income" and this compared to over 66% of mathematics and computing graduates, 72% of education graduates but only 32% of the humanities graduates and just under 36% of arts graduates.

A significant proportion of highly qualified leavers experienced a short spell of unemployment after qualifying. But most of these experiences were transitory. Despite this, for most, it took about 2 years for unemployment among the 1995 leavers to stabilise at about 2-3%. And those who pursued a course with a clear vocational content (such as engineering) were much less likely to be unemployed than those whose course was more broadly defined.

Additional qualifications, training and work experience: almost 1/5th of respondents continued in postgraduate level education after graduation. Nearly 31% of engineers had participated in a Masters degree course (the second highest proportion of the degree subject groupings). Interviews with graduates (and diplomates) suggested that the majority were highly aware of the need to continue to "collect" skills during their working lives. Work experience was perceived to be crucial as a "key to the door of the labour market". The report deduced from this that the higher education institutions should therefore further improve their links with employers to enable more work placements for students. This must also be the case in engineering even though those studying engineering are 3 times more likely to have been sponsored than graduates as a whole.

The fit between undergraduate studies and graduate jobs: respondents' career trajectories were examined in the context of the extent to which their degree was required and used in the kind of job that they had found after the three and a half years. Over 65% of the 1995 graduates in employment were in jobs that required their degrees. Graduates with vocational degrees, such as engineering, education and medicine related were most likely to be in such jobs than graduates with more general degrees such as the arts and humanities. However there did appear to be a slow convergence of career paths, as time elapsed and career paths were established.

5.7 Longitudinal studies: The DTI/Barclays National Graduate Tracking Survey 2002 and 2003

The DTI initiated a pilot study in February 2000 designed to explore the feasibility of conducting a follow-up study with individuals from earlier DTI/ Barclays first destination surveys. The pilot was completed with 1,067 interviews conducted.[109] Following these survey results, the Communications and Information Industries Directorate of the DTI commissioned a survey in 2001 and again in 2002 among those graduates initially surveyed in 1998and then in 1999. During May 2002, a total of 1,190 graduates were interviewed via telephone.[110] The report placed a particular focus on graduates who are of interest to the Information Technology, Communications and Electronics (ITEC) industry and included graduates currently employed in an ITEC occupation, engineering graduates, electronic engineering graduates and computer scientists (the "DTI subsets" or groups). The performance of these graduates is measured against the performance of the entire graduate cohort (or the "whole sample").

As to be perhaps expected the main findings are consistent with those found in "Moving On". For example, by May 2002, 92% of graduates were in employment and only 2% were unemployed. And 84% of 1999 graduates were in full-time employment. The finding that 6 months after graduation, the graduates in the DTI subsets consistently fared better than their peers in the labour market remained true 2 and a half years on. Graduates from the subsets were more likely to be in a career job than the whole sample (84% and 93% of engineering graduates and computer graduates respectively versus 78% for the whole sample). However the gap between the subsets narrowed over time, a phenomenon also noticed in the "Moving On" study (section 5.6). Over the three years following graduation, the proportion of graduates employed in a job related to their career plan increased by 22%, from 57% in 1999 to 78% in 2002. Graduates employed in an ITEC occupation were more likely to be in a job related to their career plan than those in the whole sample (87% versus 78%). And as noted above, engineering graduates and computer science graduates tended to be in a job related to their career plan (84% and 93% respectively).

Graduate salaries increased from a median of £13,750 in 1999 to £20,200 in 2002, an increase of 45%. Of the subsets or groups computer science graduates were earning the most with a median of £25,000 and they experienced the most significant increases in salary between the surveys, particularly at the top end of the market. This suggests that here demand had been outstripping supply. Engineers and those in an ITEC occupation also did well and earned medians of £22,384 and 23,000 respectively in May 2002. These salary figures are similar to those found in "Moving On" (section 5.6). This study also found that the salary-related gender difference amongst those in an ITEC role was zero (that is it did not exist). However, the gender difference in favour of males was 19% amongst engineering graduates and 13% amongst computer science graduates compared to 16% for the sample as a whole. But female graduates in the key groups or subsets continued to earn for than female graduates from the whole cohort, with females engineering graduates earning £18,822 and females computer science graduates earning £21,174 compared to £19,000 for the whole sample. Females working in an ITEC occupation or role earned £23,941 per annum.

Further training and qualifications: engineers and electronics engineers were more likely to have undertaken a short course in business or technical training compared to the whole sample. Similarly, more engineers had undertaken a programme leading to professional qualification than graduates in the whole cohort. Graduates that received training from their employer tended to be employed by large organisations. 35% of all graduates claimed to be members of professional associations compared to 56% of engineers (but only 14% of the computer scientists).

Job characteristics: over 90% of engineers identified their jobs as challenging and varied and nearly 90% identified their job with continued skills development. 92% saw opportunity to reach managerial levels and over 80% saw their organisation as progressive and dynamic. More engineers identified their jobs with these characteristics than graduates in the whole sample did. Similarly, more engineers identified their jobs with a competitive salary than the whole sample (65% versus 59%). More engineering graduates identified opportunities for an international career than graduates in the whole sample (72% versus 51%).

The next DTI Tracking Survey 2003 was published in November 2003.[111] This study consisted of 1,053 telephone interviews, using a quota sample and there was the usual particular focus on ITEC and engineering employment. 87% of all graduates were in full time employment and the key groups were more likely to be in full time employment with 94% of engineering graduates and 89% of computer science graduates being so. The key groups, particularly engineering graduates were more likely to be in a job related to their career, in a graduate job, members of a professional association and earning higher salaries. Respondents earned a median salary in 2003 of £21,000 per annum, up by 5 per cent on 2002 and those graduates in ITEC jobs earned a median of £23,000, while engineering graduates earned £24,000 and computer science graduates earned £22,000. Most of these findings not surprisingly have already been picked up above by the earlier DTI Graduate Tracking Surveys and the key findings remain the same. Graduates from the key groups do better than average in the labour market three and half years after graduation and employers are more likely to retain graduates with ITEC jobs and engineering graduates. Women in ITEC jobs and with engineering degrees enjoy a better labour market experience than females in general and females with engineering degree do particularly well. But both ITEC and engineering still fail to attract women and it might therefore be a good idea to promote the relative success of women technologists to girls at school and to look seriously at the impact of male domination on the culture if ITEC and engineering organisations.

5.8 Longitudinal studies: Mapping the Careers of Highly Qualified Workers

This was a national study undertaken by the University of Birmingham for the Higher Education Funding Council for England and the National Committee of Inquiry into Higher Education (Dearing 1997). Its main purpose was to determine the 'payback' or "rate of return" to graduates and to the state from Higher Education.[112] Amongst the wealth of data recovered were the 1996 salaries of 1985 graduates. These clearly indicate the value of a degree in Engineering – whether or not this has been pursued into professional status. The summarised data are given in table 5.14, and chart 5.3 shows them graphically; both Engineering and Mathematical (Computer) Science graduates appear in the top ten salaries, earning more than Clinical Medicine graduates (though less than Clinical Dentistry, Law and Economics graduates). And a more recent study[113] based on Labour Force Survey data pooled from 1993 to 2000 estimated the proportionate effect of a first degree broken down by degree subject, all relative to having at least 2 A-levels (and where the effects of higher degrees are not reported) and controlling for the effects of age, region and some other factors. There were found large differences in the coefficients with Law, Health, Economics, Business, Mathematics and Engineering considerably higher than Arts, Education, Languages and other Social Sciences.

6 Professional registration

The Engineering Council (UK) maintains the UK national register of professional engineers and technicians. Licensed Engineering Institutions114 who have satisfied the Council's requirements for membership processing may submit their members for registration. The members must be persons with appropriate education, training and responsible experience115. They are entered in one of three categories on the register: Chartered Engineer, Incorporated Engineer and Engineering Technician.

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6.1 Registered engineers

The majority of those registered with the Engineering Council (UK) are Chartered Engineers. Over the last ten years, the numbers registered have fallen from 197,375 to 190,402 by the end of 2003[116], representing a fall of 3.8% over the last ten years (which represents an annual compound fall of 0.36% per annum). Larger declines have been recorded on the other two categories of registrant. At the end of 1993 there were 55,004 Incorporated Engineers but by the end of 2003 there were 45,192. This represents a fall 21.7%, (which also represents an annual compound fall of 1.95% per annum). Also at the end of 1993 there were 15,565 Engineering Technicians but by the end of 2003 there were 12,824, a fall of 21.4% over ten years (which represents an annual compound rate of fall of 1.9% per annum). Charts 6.1, 6.2, 6.3 and 6.4 indicate the numbers of engineers and technicians registered, and also show the very low percentage of registrants who are women. At end-2003 3.2% of Chartered Engineers, 1.0% of Incorporated Engineers and 1.2% of Engineering Technicians were women. These figures, however, are increasing, and they can be expected to rise slowly in the future as 9.7% of new Chartered Engineers (final) in 2003 were female and between 5% to 6% of all engineering and technology graduates working were female, according the National Statistics Labour Force Survey, in 2000 and 2001.[117] For the first time in 2000 a question asking the ethnic group of registrants was put in the Engineering Council Survey of Registered Engineers; and in both the 2001 and 2002 Surveys, 2.6% of respondents respectively described their ethnicity as other than "white", with an almost identical figure of 2.7% stating this in the 2003 Survey.[118]

The totals of registered engineers (other than from the Survey – which covered only UK registered engineers under the age of 65) include registrants living overseas (in 2003 there were about 23% of Chartered Engineers and 11% of Incorporated Engineers and 10% of Engineering Technicians living outside the UK), retired registrants and the

Chart 6.1: Total Chartered Engineers
(Source: Engineering Council (UK))

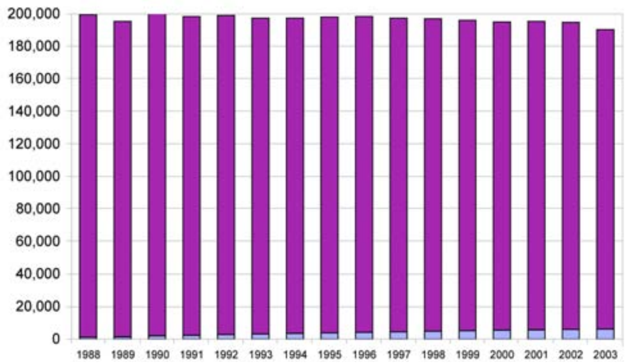
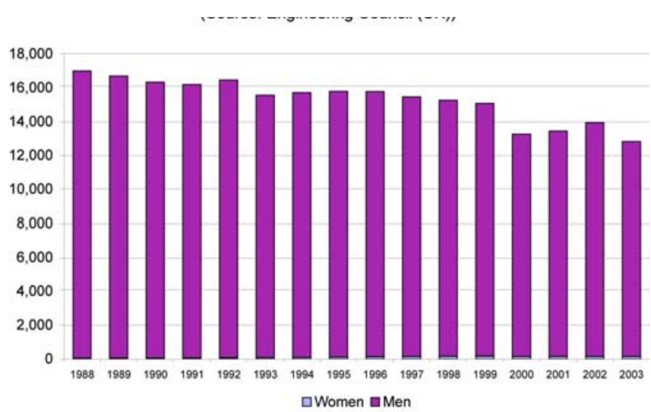


Chart 6.2: Total Incorporated Engineers
(Source: Engineering Council (UK))

Chart 6.3: Total Engineering Technicians
(Source: Engineering Council (UK))



small number of registrants likely to be unemployed. It is estimated that about 153,856 registrants are likely to be working in the UK at the end of 2003.

Data constructed from 1988 to 2003 of registrants of working age only suggests that the number of Chartered Engineers of working age have been or are declining currently at the rate of 1.3% per annum (Chart 6.5); this is a higher rate of decline than for Chartered Engineers as a whole and reflects the increase in age observed over this period. Data for the number of Incorporated Engineers and Engineering Technicians of working age for the same period 1988 to 2003 suggests that declines of 2.7% and 2.6% per annum have been occurring (Charts 6.6 and 6.7). These higher rates of decline for registrants of working age recorded when compared to registrants of all ages reflects the increase in the age of registrants observed over the period 1988 to 2003, as clearly demonstrated in Charts 6.8, 6.9 and 6.10.

Other data, albeit limited, suggests that the UK has about the same number of registered engineers as other developed countries when seen in the context of registered engineers as a percentage of the population and as a percentage of engineering graduates (see table 6.1).

6.2 New registrants

Chart 6.11 shows the numbers of new additions to the Register annually for the past fourteen years. The remarkable surge in Chartered Engineer registrations in 1990 (see Chart 6.11) reflects the award of Licensed Member status to the British Computer Society (BCS) and the resulting admission of 4,249 Chartered Engineers from that Society that year. Chart 6.12 shows the percentage of new registrants who were women over the same period, and this clearly indicates the slowly increasing numbers of women choosing to seek professional recognition, albeit from a very low base and particularly those who become Chartered Engineers. Again, the large variation in 1990 was associated with the BCS, and reflects the relatively higher proportion of women among computer scientists.

In the Engineering Council 2001 Survey of Registered Engineers questions were asked with the aim of finding out the main reasons why members of institutions had become registered engineers in the last 12 months. As can be seen from Chart 6.13, the main reasons given for becoming a registered engineer were “Recognition of my professional achievement/qualifications/status” (49.5%), “To help with my career developments/promotions” (31.8%) and “To improve my job prospects/membership required by the prospective employers” (18.6%).

Chart 6.4: Total Registered Engineer
(Source: Engineering Council (UK))

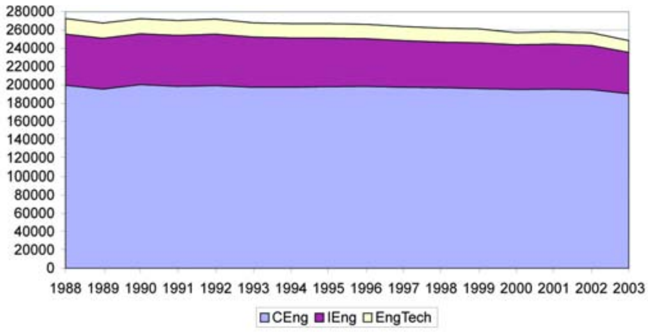


Chart 6.5: Number of Chartered Engineers of Working Age 1988 to 2003
(Source: Engineering Council (UK))

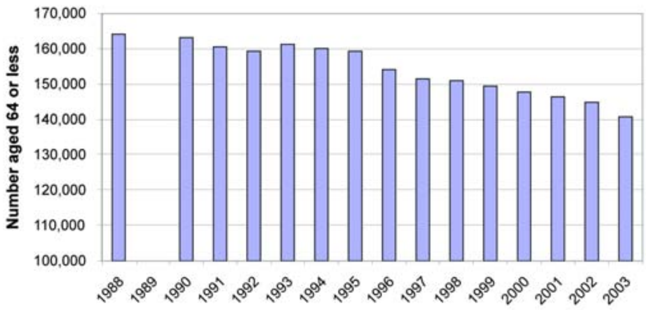


Chart 6.6: Number of Incorporated Engineers of Working Age 1988 to 2003
(Source: Engineering Council (UK))

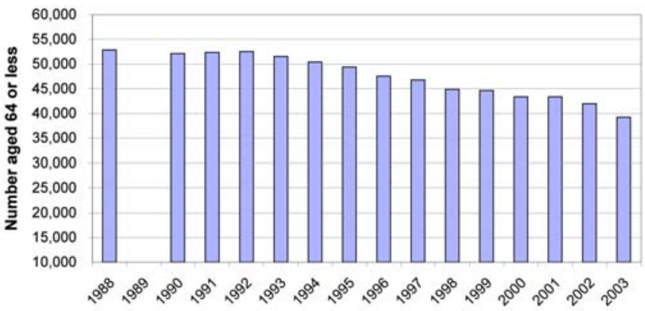
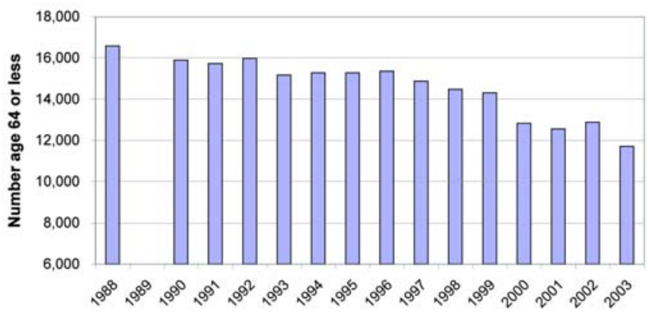


Chart 6.7: Number of Engineering Technicians of Working Age 1988 to 2003
(Source: Engineering Council (UK))



6.3 European Engineer registration

Since 1987, the European Federation of National Engineering Associations (FEANI) has awarded the European Engineer (EurIng) title to engineers able to demonstrate a total of seven years' higher education, training and experience (of which a minimum of three years must be of accredited higher education). Most UK registered Chartered Engineers are, therefore, eligible for the title, and in fact more UK registrants have applied for the title than engineers from any other member country of FEANI. Chart 6.14 shows the total EurIng award holders by country, with the UK column being truncated to allow some detail of the other countries involved. By November 2003 there was a Europe-wide total of 27,607 European Engineers, of whom 14,143 were from the UK. France had a total of 2,540, Spain 2,477 and Germany 2,429.

Chart 6.15 shows the five countries with the overall highest numbers of EurIng holders as at year-end 2003, and shows the progression of applications annually over the last fifteen years. By around 1993 it would appear that FEANI had absorbed the 'backlog' of potential EurIng registrants in the UK, and since that time there have been a significantly smaller – but steadier – number of registrations – around 300 to 600 per year (equivalent to around 9% of new Chartered Engineers). When invited every five years to renew their registration, around 90% of UK European Engineers do so.

For a number of reasons the UK has only ever put forward applications by Chartered Engineers for European Engineer registration, although under SARTOR 3rd Edition's revised educational requirements, applicants for Incorporated Engineer will also be required to hold a 3-year degree (or equivalent qualification). In this context, the answers to one of the questions posed in the Engineering Council's 1999 Survey are particularly interesting (see table 6.2). Asked how important they felt it was to become a European Engineer, 5% of Chartered Engineers felt it was essential and a further 45% thought it useful. Incorporated Engineers and Engineering Technicians had higher hopes for European registration, however; 60% of each thought it was useful, with over 10% of each believing it essential. This response suggests there is a healthy demand for an appropriate form of registration in Europe for engineering professionals other than Chartered Engineers, and the Engineering Council (UK)'s International Department continues to work towards this goal. This may reflect the fact (Engineering Council's 1999 Survey) that 59% of UK registrants thought that the effect of the European Union on their work would be positive, while only 14% held a negative view.

Chart 6.8: Chartered Engineer - Age Profile 1988/2003
(Source: Engineering Council (UK))

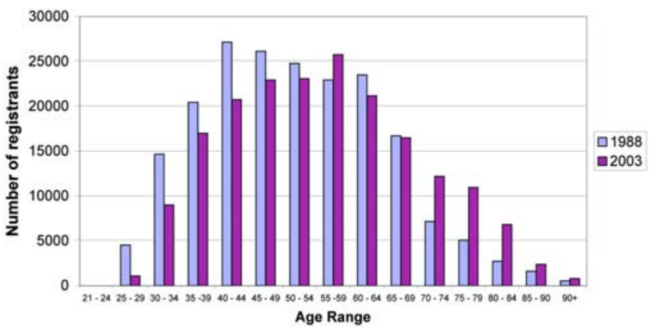


Chart 6.9: Incorporated Engineer - Age Profile 1988/2003
(Source: Engineering Council (UK))

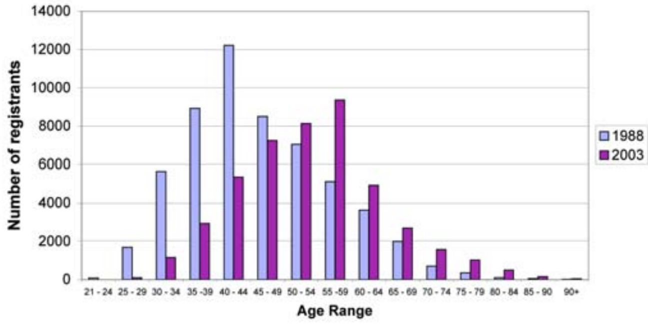


Chart 6.10: Engineering Technician - Age Profile 1988/2003
(Source: Engineering Council (UK))

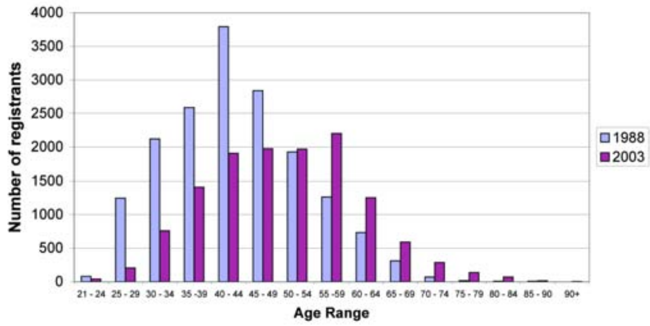


Chart 6.11: New registrants 1988 - 2003
(Source: Engineering Council (UK))

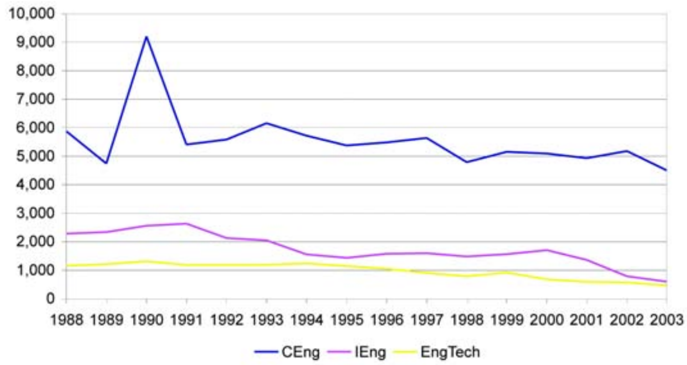


Chart 6.12: Percentage of new registrants who are women
(Source: Engineering Council (UK))

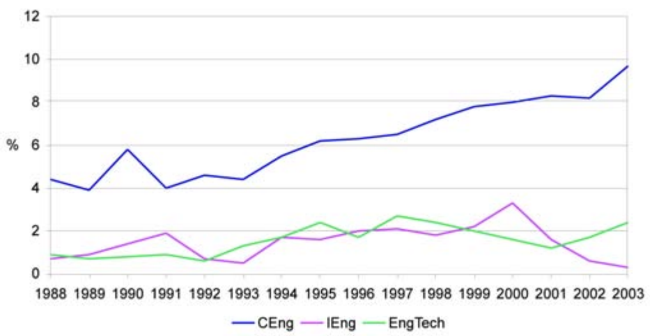


Chart 6.14: Total EurIngs per FEANI member country 2003
(Source: FEANI)
[13,499]
UK = 14,143

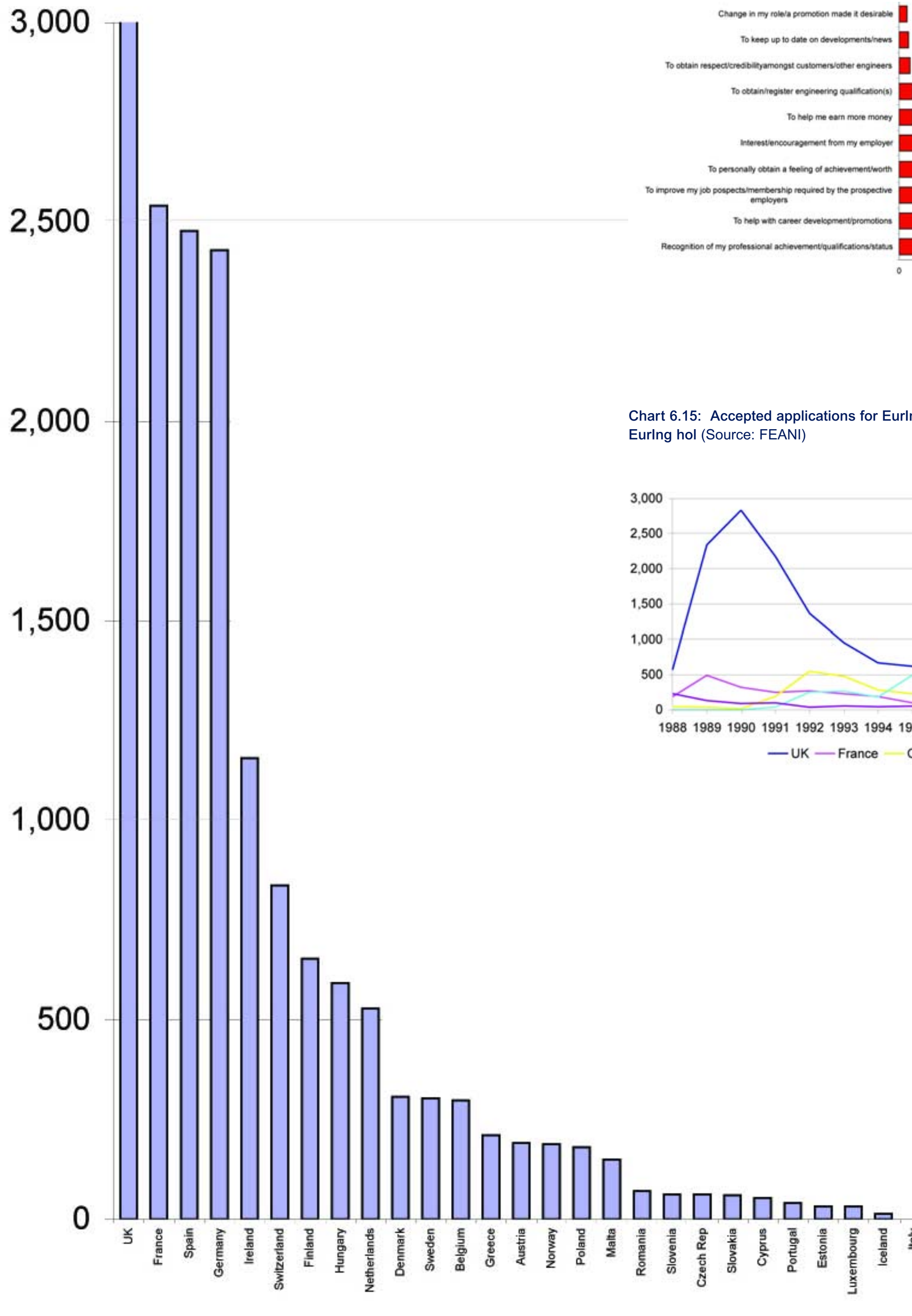


Chart 6.13: What was your main reason for becoming a registered engineer?
(Source: Question 45, Survey of Registered Engineers 2001)

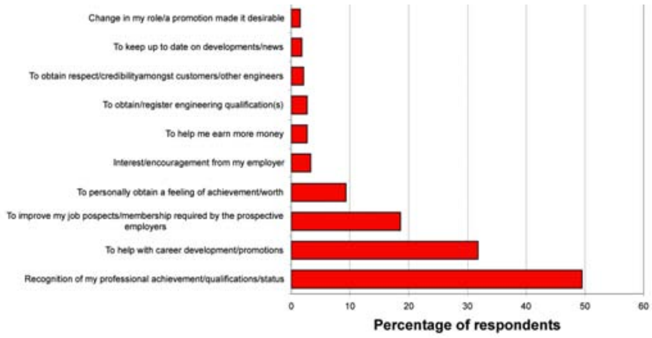
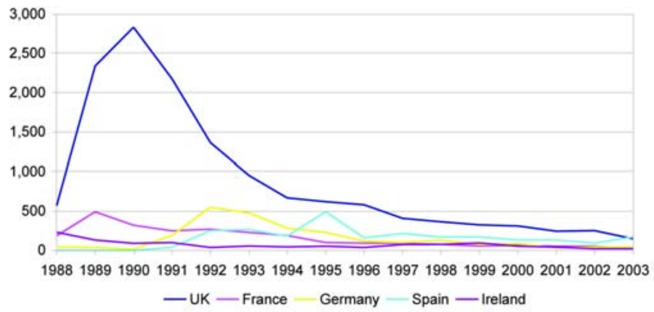


Chart 6.15: Accepted applications for EurIng (five countries with largest number of EurIng hol (Source: FEANI)



For the first time the Engineering Council Survey of Registrants 2000 asked two questions on “globalisation”, in view of the powerful effect that it is has in driving technological and economic change within the UK. Nearly 39% of registrants stated that Europe was the region which had most influence over their work. This was the largest proportion, followed by North America (16.1%). Just over one third of respondents (34.9%) stated that no international region at all had influence over their work.

Attitudes to the impact of globalisation seemed generally favourable. More than a third of respondents indicated that globalisation has a positive impact on their job. Just one respondent in 12 (8.4%) stated that it had a negative effect on their job. Fewer than one in 10 respondents in any registration category indicated that globalisation had a negative effect on their job. 40.6% of Chartered Engineers believed that globalisation had a positive effect on their job. They were also the group which were most likely to have stated previously that there was international influence over their work.

7 Employment conditions

7.1 Salaries of engineering employees

Information on the earnings of the UK workforce is collected by the UK annual New Earnings Survey (NES) and published by the Office for National Statistics. The New Earnings Survey gives details of weekly earnings of employees and the self-employed, using the Standard Occupational Classification[119] as the basis for employee categorisation. The classification 'professional engineer or technologist' is intended to apply only to those who are members of professional engineering Institutions, or who hold a degree or a Higher National Diploma or Certificate in engineering or technology.

The published details from the January 2003 New Earnings Survey are given in table 7.1. The average annual gross earnings (including overtime) for all those classified as professional engineers and technologists was £33,324 in the year ending April 2002. By contrast, the average annual gross earnings (including overtime) for registered Chartered Engineers in the year to April 2003 was £49,088 according to the Engineering and Technology Board 2003 Survey of Registered Engineers (and this had fallen from £51,960 for the year ending in April 2002). This rather large difference between the national data and the survey response from the profession could stem from a number of causes. However it is clear that, whatever the cause, registered engineers earn considerably more than the national average for the equivalent SOC[120]. However there is a suspicion in some engineering circles that not all those so classified in the NES are really 'professional engineers.'

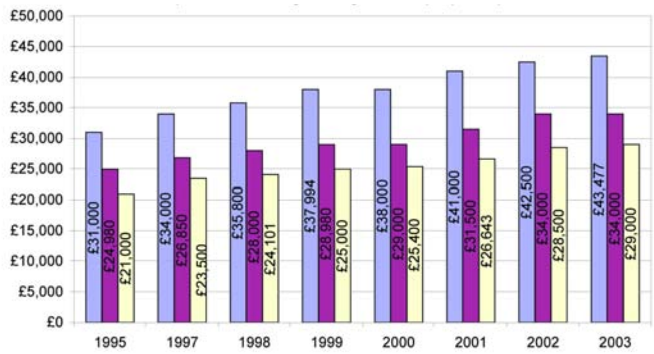
7.2 Salaries of registered engineers and technicians

Amongst a wealth of other data collected about registrants in the biennial Engineering Council Survey of Professional Engineers and Technicians is information on their annual earnings. The headline figures for average and median earnings of registered engineers and technicians are shown in tables 7.2 and 7.3; these use data from the 1995, 1997, 1999 and 2001 Surveys, as well as salary information collected in the supplementary surveys in 1998, 2000 and 2002 and in the Engineering and Technology Board 2003 Survey of Registered Engineers. Median earnings are also shown graphically in chart 7.1. The average (median) Chartered Engineer salary was £43,477 (up from £42,500 in 2002) in the year to 5 April 2003, while for Incorporated Engineers it was £34,000 (no change from 2002). Engineering Technicians' median salary is now £29,000, an increase of 1.8% on the 2002 figure.[121]

Charts 7.2, 7.3 and 7.4 show the distribution of responses for each class of registrant by earnings bands. They demonstrate that, notwithstanding a small number of registrants earning considerably in excess of the average (pulling up the average figure), the bulk of responses is clustered around the median figure.

Figures published by the Royal Institute of British Architects (RIBA) show that over the year to April 2003, its members had median earnings of £35,000[122]. Architects employed as principals in partnership had median earnings of £47,000 and were therefore very close to those of Chartered Engineers (see above in 7.2). New Earnings Survey data also indicated that during the year ending April 2002 the

Chart 7.1: Median annual earnings of registered engineers and technicians, 1995-2003 (Source: The Engineering Council (UK), ETB)



hart 7.2: Percentage distribution of responding Chartered Engineers' earnings, year to 5 April 2003 (Source: The Engineering and Technology Board)

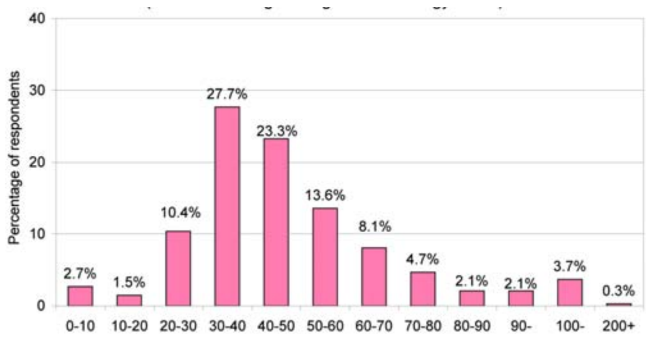


Chart 7.3: Percentage distribution of responding Incorporated Engineers' earnings, year to 5 April 2003 (Source: The Engineering and Technology Board)

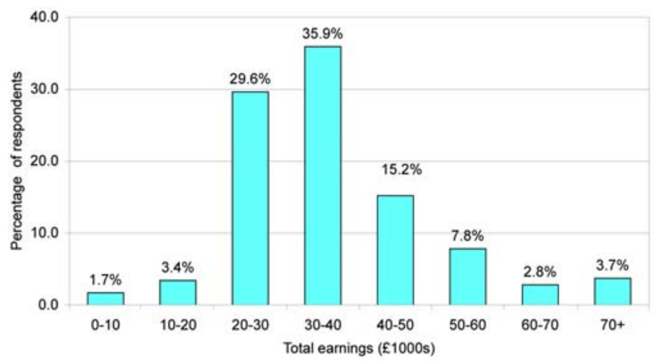
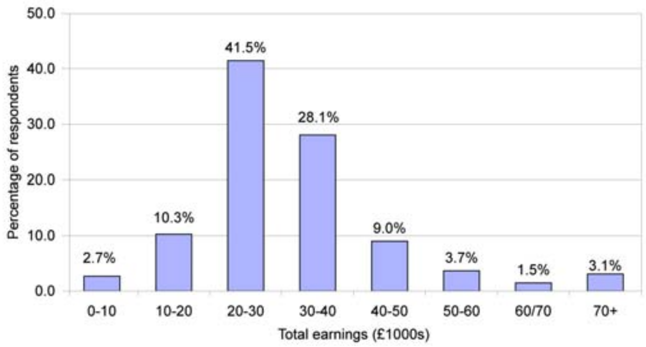


Chart 7.4: Percentage distribution of responding Engineering Technicians' earnings, year to 5 April 2003 (Source: The Engineering and Technology Board)



average (mean) gross earnings of Computer Systems and Data processing Managers was £47,886, an increase of 4% on the previous year. And New Earnings Survey data published in 2003 for the year ending April 2002 gave annual average gross earnings of £36,176 for chartered, and certified, accountants, £53,982 for health professionals and £45,580 for solicitors. When looking at New Earnings survey data, as the distribution found is usually statistically normal, it is better to use the mean as a measure of the average value. This is not the case with the results of the Surveys of Registered Engineers as the distribution of earnings found is statistically non-normal and skews to the right; this is due to the number of individuals with high earnings that are found and who are likely to be working at senior levels e.g. as Directors of large companies. Mean values in these circumstances are also likely to be less stable over time than the median values observed; hence is better to track median values if you wish to observe a trend, as is undertaken here.

While it is evident from the above that Chartered Engineers are paid well compared to other professional groups, on the other hand there is evidence from our Survey and other sources that civil engineers are, on average, paid less than engineers from other disciplines. The statistics from the Office of National Statistics New Earnings Survey found that all engineers and technologists earned an average (mean) of £33,324 in 2002. Civil, structural, municipal, mining and quarrying engineers earned £31,527 while electrical and electronic engineers earned £34,573 and £35,133 respectively (see Table 7.1). The evidence from our own statistically representative 2001 Survey of Registered Engineers indicates more marked differences between disciplines amongst Chartered Engineers. Chartered Engineers who were members of the Institution of Civil Engineers earned an average and median of £42,260 and £36,000 respectively compared to those who were members of the Institution of Chemical Engineers - £59,479 and £46,037 respectively (see Table 7.4 for this and other comparisons).

7.3 Unemployment rates

The Engineering Council (UK) Survey of Registered Engineers and The Engineering and Technology Board ask respondents whether they have been unemployed and seeking re-employment at any time in the last year. Table 7.5 shows the percentage who replied 'Yes' for each of the last eight surveys (including 2003). The numbers show a decline over the documented period up to 1999 followed by increases thereafter in line with general trends of the labour market for the UK economy over this period. In 2002 unemployment in all three categories of registrant was the more or less the same as in 1995, although the figure rose in 2003, reflecting the less buoyant figures for economic activity in 2002. In 1995 unemployment for the whole of the economy as measured by the ILO count averaged 8.8% of the labour force in the three months to April 1995. By the spring quarter of 2002 it had fallen to 5.2% measured on the same basis and in April 2003 it was down slightly to 5.0%. The claimant count measure was 3.2% in both April 2002 and April 2003. Similarly, the percentage of those registrants describing their current employment status as 'unemployed and seeking re-employment' decreased, from 2.3% in 1995, through 1.4% in 1997 to 1.2% in 1999 and 2000 and just 0.9% in 2001, although there was a rise to 1.6% in 2002 and another increase in 2003 to 1.8%. These relatively low levels of unemployment within the profession indicate the continuing high level of market demand for registered engineers.

7.4 Responsibilities

In the 2001 Engineering Council Survey of Professional Engineers and Technicians, registrants were asked to indicate the extent of their responsibility for technical matters. Table 7.6 shows the responses by category of registration[123]. Nearly one quarter of Chartered Engineers and nearly one fifth of Incorporated Engineers said that they were responsible for all technical aspects of a major engineering operation, project or plant, as did 12% of Engineering Technicians. Another 24% of Chartered Engineers, 25% of Incorporated Engineers and 23% of Engineering Technicians had responsibility for all technical aspects of a complete operation, project or plant. Only 9% of EngTechs, 6% of IEngs and 5% of CEngs had their responsibilities limited to minor technical details only. A significant proportion (16% of CEngs and 12% of IEngs and EngTechs) had no technical responsibilities, having moved to other areas of responsibility such as teaching, commerce or administration.

A large proportion of respondents also stated that - other than complying with policy - their work was largely unsupervised, and at most only occasionally reviewed in outline; well over 80% of respondents in all sections of the Register said this. The breakdown by category of registration is shown in table 7.7. Table 7.8 also shows responses to a question about the extent of respondents' authority, and demonstrates that 71% of Chartered Engineers, 61% of Incorporated Engineers and 54.5% of Engineering Technicians had management or supervisory responsibilities. Overall, registered engineering professionals felt they enjoyed a high level of responsibility and autonomy within their chosen area of work.

7.5 Training and development

In view of the on-going discussion of skills shortages[124] and the increasing emphasis on the need to maintain an up-to-date knowledge of current practice, training and development issues have growing importance.

The Science, Engineering and Manufacturing Technologies Alliance (SEMTA – formally EMTA) conducts a periodic labour market survey of the engineering manufacturing industry, the most recent reports being the October 1998, the November 1999 and the July 2002 Labour Market Survey[125]. SEMTA Surveys were not undertaken in 2000 and 2001.

Employers are asked about a number of issues, including their current training policy and activity. Overall, 61% responded that they had offered some on-the-job training in the last year, though the figure varied significantly by size of establishment, from 55% of small companies (employing 5-49 staff) to 95% of those employing 250 or more. There were no significant differences by industry sector. However, almost half the companies indicated that on-the-job training was funded or organised for less than a quarter of their employees (table 7.9 shows the detail). Approximately 80% of companies had offered training delivered by a fellow member of staff, and 46% had involved an external training provider.

Companies were also asked about their provision of off-the-job training for their employees (specifically those aged 25 or older), and half indicated that they had funded or arranged such training in the previous 12 months. Again, this varied by size of establishment, with 43% of those with fewer than 50 employees offering training, but 93% of those employing 250 or more doing so (see table 7.10). The majority of this training was delivered in the form of short courses, but day release and evening and part-time courses were also common, while distance learning and full time courses were relatively rare (table 7.11). Off-the-job training was, in general, available to a wide range of employees (table 7.12).

The latest 2002 SEMTA Labour Market Survey found that overall the proportion of companies funding or arranging training held up remarkably well at 64 per cent, which was the same as found in 1999 and slightly more than in 1998 (60 per cent). However concern was expressed at the apparent significant decline in the number of companies employing apprentices or other recognised trainees, at only 28 per cent in 2002, compared with 38 per cent in 1999 and 39 per cent in 1998. Reasons for this are not clear but the trend is consistent across all sectors (with the exception of Electronics where the percentages in 1999 and 2002 were similar). It is possible, however, that the disruption caused by the setting up of the Learning and Skills Councils and the short term loss of the previous Training and Enterprise Council promotional and recruitment activity may be a factor. It is to be hoped that this trend will soon be reversed, given the government's drive for increased numbers of Modern Apprenticeships generally and SEMTA's own targets for Engineering Modern Apprenticeship recruitment set out in the 2001 – 2005 Workforce Development Plan for the sector.

Recent research published by the Engineering and Technology Board[126] presented evidence about the extent to which recent graduates received or undertook further education or training since gaining their degree in 1995; this data was obtained from a Career Paths Survey.[127] There was found a substantial degree of variation by subject studied in the extent to which graduates undertook further study or had some experience of organised training via short courses. For law graduates, the need for further professional qualification among those wishing to continue in the profession is revealed by the fact that 40 per cent stated that they had undertaken a professional qualification since gaining their 1995 degree. However, it was noted that among engineering graduates there was found the highest percentage stating that they had undertaken no further study since. But this was, in part, because a significant proportion of graduates from other disciplines such as arts, humanities, languages and, of course, law had undertaken a postgraduate certificate or diploma course, which often related to the acquisition of a teaching credential. Nevertheless, the relatively low proportion of engineering graduates who had engaged in short courses or had gained a further qualification is perhaps rather surprising. In order to attempt to shed further light on this, data was extracted from the Labour Force Survey to investigate whether or not there was a similar picture in terms of the information concerning work-related course among engineering graduates.[128] It was therefore possible to find the proportion of those by degree subject who had received work-related training in the 4 week period prior to the survey and in these somewhat general terms it was found that engineering and technology graduates reported the lowest experience of work-related training.

The 2001 Engineering Council Survey of Registered Engineers asked individuals about their experience of training, both employer-sponsored and privately funded. In the year to April 2001, 54% of all respondents (and over

55% of the Incorporated Engineers and Engineering Technicians) had undertaken five or more days of employer sponsored training, while 16% had funded their own training for their current work. Also the proportion of respondents indicating that they had undertaken each of the listed types of training had increased since 1999, most notably among those partaking in employer sponsored training. This could be recognition, by those involved, of the increasing importance of lifelong learning and continuous professional development. As technology changes quickly engineers have to keep on learning throughout their working lives.

Table 7.13 shows the response for each section of the register, and table 7.14 shows the method of delivery used. As in the SEMTA survey, the most common form of delivery of all types of training was via courses, while on-the-job training was also quite widely undertaken.

7.6 Skills shortages

The 1999 SEMTA Survey was in effect a second survey undertaken to focus on the skills and training issues highlighted in the previous (1998) Survey by engineering manufacturing employers. 32,000 establishments with 5 or more employees and employing a total of 1.67 million people were examined. 91,000 professional engineers were identified, with the major employing sectors being electronics and aerospace. 110,000 "Technician Engineers" and Engineering Technicians were found, with the major sectors being electronics, aerospace and "other transport". 71% of all establishments reported a shortage of technical engineering skills. The percentage was highest (76%) in the electrical equipment sector and the lowest (58%) in "other transport". In the latest 2002 SEMTA Labour Market Survey, the field work took place in the fourth quarter of 2001, two and a half years after the previous (1999) Survey. In 2002 32,000 establishments with 5 or more employees and employing a total of 1.55 million people (7 per cent down on the 1.67 million found in 1999), were examined. 91,000 professional engineers were identified, the same number found in 1999; the major sectors employing them again being electronics, electrical equipment and aerospace. 132,000 Engineering Technicians were found, 20 per cent more than in 1999, with the major sectors being electronics, aerospace and electrical equipment. 78 per cent of all establishments reported a shortage of technical engineering skills. This figure is up from the 71 per cent found in 1999 and it covers activities in which the core workforce of Professional Engineers, Technicians, Craftpersons and Operators/Assemblers would be employed. It is striking and perhaps of some concern that technical engineering skills account for the major skills lacking when compared to other skills categories such as key or core skills (literacy and numeracy, communications and people skills), general IT/computers, management and marketing/sales.[129]

Engineering skills have traditionally occupied a central position in policy discussions concerning the national economy because of the long lead-times required to produce these skills at both intermediate and graduate levels. Also engineering skills are utilised throughout the economy.

The Science, Engineering and Manufacturing Technologies Alliance (SEMTA) labour market surveys showed (see above) that the highest proportion of establishments reporting hard to fill vacancies were in craft-intensive sectors such as motor vehicles, aerospace, metal products and mechanical engineering. Other notable areas of recruitment difficulty were technicians in electronics and aerospace and professional engineers in the electronics industry. Research published in 1999 for the Skills Task Force[130] analysed information on the extent of recruitment difficulties outside the engineering manufacturing sector as well as inside it. This report, however, dealt solely with engineering skills and knowledge at graduate level in IT, engineering and science. Employers of engineering, science and information technology graduates were surveyed in a mix of manufacturing and service sectors in the first quarter of 1998. The report found that some 35% of enterprises in electronics manufacturing had found some difficulties in meeting their recruitment targets over the last three years. In mechanical engineering, and in three leading service sector industries, 19-26% of enterprises experienced similar difficulties. In the case of the service sector industries the single most important discipline in shortage was computer sciences and information technology rather than any engineering subject. However this study also found that the problems electronics companies had in recruiting electronic graduates were emphasised by competition from higher-paying employers in computer and financial services who were both willing and able to fill their information technology vacancies with electronics graduates. By contrast the reverse is not usually true, as computing and information technology graduates do not have the skills and knowledge necessary for the electronics industry. However, with the IT boom associated with the year 2000 now well over, this may not now be so evident.

This general picture on skills shortages was reflected in DTI White Papers and other related publications at about this time. In the DTI White Paper on “Excellence and Opportunity: a Science and Innovation for the 21st Century”, published in July 2000. It said, in Chapter 3, paragraph 17, that “There are important mismatches between supply and demand; particularly shortages of electronics engineers, computer scientists and of people with the technical skills to do the new jobs created by the knowledge economy”.[131] However this probably reflecting the tightness of the labour market which was then associated with the IT boom brought about by the extra needs of the year 2000 and this is of course now over. Thus it is not surprising that in subsequent publications including the 2001 White Paper “Opportunity for All in a World of Change: Enterprise, Skills and Innovation” and the December 2003 DTI Innovation Report "Competing in the Global Economy: the innovation challenge”[132], there is no subsequent statement supporting the idea of significant mismatches of supply and demand in SET occupations. The science and engineering base was stated as being strong in the UK when compared to our major competitors and the problems that we probably had were related to other factors in the innovation process.

As the First Report of the National Skills Task Force[133] pointed out, there is a need for a stronger and more reliable base of information on labour market and skills needs. This still seemed to be the case in 2001 when the Engineering Sector Skills Dialogue was published.[134] This report drew on work undertaken by a wide variety of sources including the Employer Skills Survey (ESS), which was conducted in 2000, and Projections of Occupations and Qualifications by the Institute for Employment Research[135] as well as the NTOs' own Skills Foresight research. However the report was primarily concerned with the demand and supply of skills in the engineering manufacturing industry, which is a subset of the manufacturing sector. Nevertheless, it did address the issue of engineering skills across the economy, although not in as much depth. It certainly recognised that engineering skills were represented in most sectors of the economy and are used in many and diverse ways - from the manufacture of a wide range of goods to supporting business and communications infrastructures, public health and defence. The report also recognised that the service sector also included technical or engineering consultancies, and specifically managing contractors working on engineering construction projects. Engineering has traditionally occupied a major role in the UK economy, and continues to do so, despite the relative decline in the manufacturing as a proportion of the total economy. This is so because engineering skills are utilised throughout the economy and, in particular, are crucial to the development of technology-based industries and services.

In general it would appear that for engineering occupations in general supply appears to be more or less equivalent to demand. However there are specific shortages documented from responses by employers. In engineering manufacture there seems to be a shortage of professional engineers in the electronics sector and elsewhere in construction. The demand for civil engineers and other engineers in construction is very strong, but still not fully reflected in relative salaries. However construction is a highly cyclical industry and has been responding to a boom in transport-related work and the strength of the property market. Superimposed on the picture of relative balance is the apparent dissatisfaction of employers with the skills that graduates have. A constant theme over past years has been a demand for "high calibre" graduates. The Skills Dialogue report found that the skills the engineering employers had most difficulties finding in professional engineers included, firstly, technical and (other) practical skills; then advanced IT and software skills; and thirdly problem solving skills in order of difficulty. However generally high levels of proficiency were reported amongst all occupations including professional engineers. Very few studies have really addressed sector specific needs in terms of technical and practical skills. The EMTA 1999 Labour Market Survey did explore technical deficiencies in greater detail and the most commonly reported skills gaps were CNC machine operations; mechanical engineering and CAD/CAM/CAE. And the EMTA 2002 Labour Market Survey found that the most frequently mentioned skills gaps, when also exploring technical deficiencies, were for CNC machine operation (21%), assembly line/production robotics (9%) and general engineering (8%).

But one of the main findings of the 2002 SEMTA Labour Market Survey was that it found a generally less buoyant industry and labour market than in the previous 1999 and 1998 surveys. The 2002 survey indicated that 57 per cent of establishments had recruited new or replacement staff in the previous 12 months, compared with 63 per cent in 1999 and 66 per cent in 1998. The level of current vacancies was also lower at 12 per cent, compared to 21 per cent in 1999 and 28 per cent in 1998; and the proportion of those that did recruit and who experienced recruitment difficulties was 24 per cent compared with 36 per cent and 49 per cent in 1999 and 1998 respectively. The proportion identifying a gap between the skills of their current workforce and the skills required to meet their business objectives were 16 per cent , 26 per cent and 32 per cent respectively in 2002, 1999 and 1998. All these are, of course, indicators of reduced economic and labour market activity. But SEMTA in the 2002 survey still found significant hard-to-fill vacancies and skills gaps in the engineering manufacturing industry. In numeric terms, the largest number of hard-to-fill vacancies were for craft and operator/assembler jobs. However, in relation to size of the workforce in different occupations, craft, technician and professional engineer jobs were the most significant in terms of being hard-to-fill. In particular, welders and a wide range of CNC jobs were hard-to-fill. Hard-to-fill vacancies for design engineers, machinists, machine operators, sheet metal workers, project managers and tool makers also occurred in fairly large numbers. Finally a report published in 2003 by the Engineering and Technology Board[136] found that while technicians, broadly defined to include not only engineering technicians but also science technicians and the electric and vehicle trades, perform a range of roles, exercise a wide variety of skills, the numbers entering these occupations is in persistent decline. At the same time UK industry is experiencing real problems in both skills shortages and skills gaps at technician level across a wide range of these occupational fields. This report thus added to the evidence that a skills shortage exists amongst quite a few technician occupations.

Also in 2003 the Engineering and Technology Board published research[137] which looked at, among other things, the skill requirements of small and medium sized enterprises (SMEs) in the manufacturing sector and the nature of skills gaps and the reasons why they occur amongst SMEs in the manufacturing sector. And perceived skills gap were found to be far more in evidence in relation to the higher skilled engineering roles. In roles while they do require a relatively high qualified staff, they nevertheless appear to be notable easier to fill. But why are these higher skills harder to come are by? Well as far as the SMEs themselves are concerned the main cause relates to a basic inability to attract young people into technology related careers; this was identified by 62 per cent of SMEs. This may well relate to, at least in part, to the demise of the traditional system of craft apprenticeships (mentioned by 57 per cent of them). Other concerns expressed were that government policy had ignored SET for too long (49%) and that the education system was not geared up so as to provide people with the right skills (46%). There was also the concern that other industries could afford to pay more than manufacturing (42%). All this led to the report's conclusions that more young people had to be attracted to the engineering profession; also employers felt that this task was best addressed at an early age by way of the education system. However SMEs themselves could do more to help fill these skill gaps in the future through training more people internally and using the strategy of encouraging continuous professional development (CPD).

But it is important to understand that, while these survey methods might well be sufficient in identifying skill gaps currently perceived by employers[138], they give little indication of long term business conditions or objectives. Any assessment or conclusions using this survey methodology presupposes that the current business objectives set by most employers are consistent with future success in competitive markets and that businesses have a full understanding of the skill levels required in the medium and long term. If this is in fact not the case and these conditions are not met in engineering and other firms where engineers work, then these companies may conceivably be experiencing "concealed" or "latent" skills shortages or gaps.

Given the long lead times needed to train technicians and graduate engineers and the reaction of employers particularly during economic recession, it seems reasonable to argue that many skills problems observed could in fact be structural in nature. Institutional arrangements and incentive structures[139] surrounding training decisions do not always appear to have succeeded in encouraging employers to support training right through the business cycle. Recent Engineering and Technology Board research backed this up by concluding[140] that too many SMEs take the attitude that they would prefer to recruit people with the skills already developed than have to bother with training people. 34 per cent of companies with poor staff retention try to recruit staff with the right skills and experience already rather than attempt to train any up, while only 23 per cent of companies with good staff retention follow this policy and as these companies are more willing to accept that they will need to take on people with more limited experience and then train them up themselves. And of course one of the main problems faced by SMEs in arranging training for staff is simply the time constraints involved. If there is only a department of 6 people and the need to train takes up one day a week then the impact on the business is significant. In these circumstances the cost of training itself is often less significant than the limitations of time, although this too can be seen as another cost. Finally periodic recessions and headlines drawing attention to redundancies that do not disregard between skilled and unskilled labour, may have given engineering an insecure image thereby deterring employees from training.

Deficiencies in short-duration training also appear to be structural. The 1998 SEMTA Labour Market Survey (see above) found that even when recruitment difficulties were pronounced, as many as 60% of engineering establishments identified the cost of training existing staff as a barrier. The 1999 EMTA labour market survey also found that the two most frequently mentioned barriers to training were being unable to afford to release staff for training and the cost of training in the local area. Particularly mentioned as high costs were IT training and CNC training. The 2002 SEMTA Labour Market Survey came to very similar conclusions with very few changes observed.

7.7 Objective measures of skills shortages

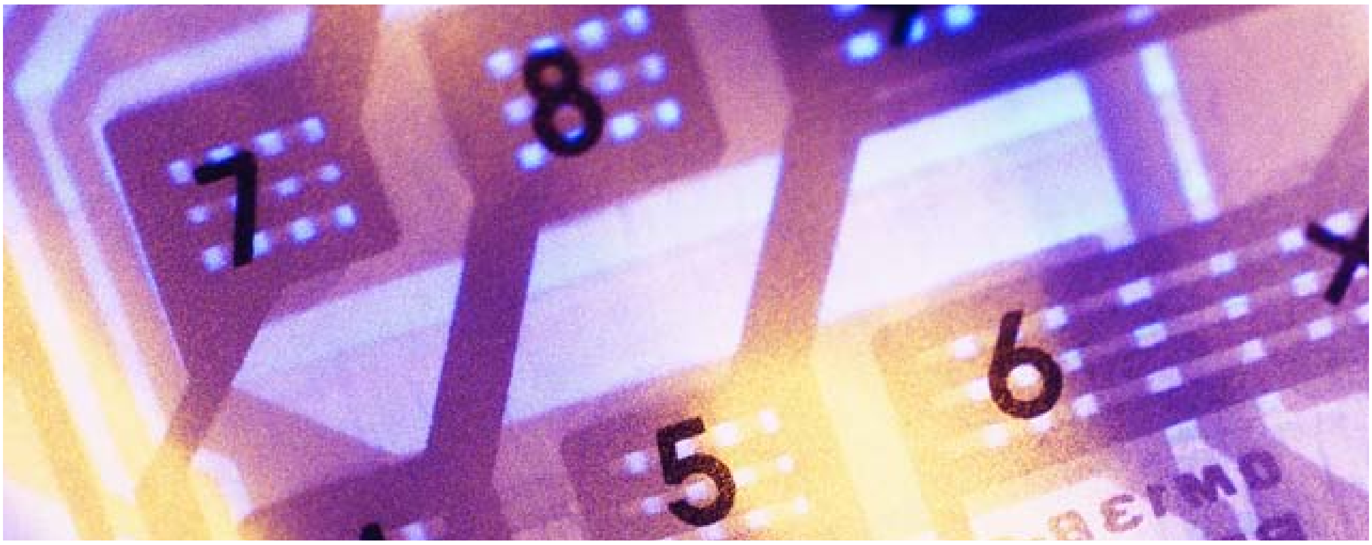
A welcome development in recent years has been the progress in the analysis of Information and Communication Technology (ICT) labour market trends. Here objective measures of skills shortages have been devised and have been used by the Home Office and Work Permits (UK) to draw up a list of occupations for which work permits can be fast tracked[141]. Indicators currently used include:

- Pay rate data provided by Computer Weekly/SSP giving average annual pay rates offered for ICT positions and IT jobs.
- The Recruitment Confidence Index, a quarterly survey conducted by Cranfield School of Management/The Telegraph; this gauges employers future recruitment intentions and expected difficulties in securing ICT staff.
- Stocks and changes of stocks of ICT occupations, source the ONS Labour Force Survey.
- Redundancies in the ICT industry, source the ONS Labour Force Survey.
- Advertised demand for the main ICT skills, provided by Computer Weekly/SSP.
- Percentage of firms with difficulty recruiting ICT, source Reed and Cranfield University/The Telegraph.

While nothing like this as yet exists for engineering and technology occupations, it must be hoped that in the near future the combined resources of the Department of Trade and Industry, the Home Office and the engineering profession will be able to produce similar data that can objectively track short term changes in engineering skill shortage trends.

In 2000 6,626 professional engineers and technologists located outside the European Economic Area (EEA) were granted work permits and first permissions; 2,736 of these were computer and software engineers. Engineer and technology professionals accounted for 10.3 per cent of the total numbers of work permits and first permissions granted in 2000.[142] However, with the IT boom associated with the year 200 now well over, the number of permits granted to computer and software engineers may not now be much lower.

8 Engineers in the economy



8.1 Engineers heading the FTSE 100 companies

Research jointly commissioned by the Engineering Council and the Royal Academy of Engineering (undertaken by the Institute for Employment Research)[143] examined the academic and professional qualifications of the directors and top executives (CEO, Executive Chairman or equivalent designation) of those companies listed on the FTSE 100 at 1 December 1997. The findings indicated that the message of Engineers in Top Management was that the myths that engineers do not make it to the top, and that the UK economy is almost entirely run by accountants, are simply not true.

It was found that 16% of directors of FTSE 100 companies (both executive and non-executive) with a first degree had studied engineering. This was marginally higher than the proportions who had studied science subjects or economics. When professional qualifications were considered, professionally qualified accountants outnumbered professionally qualified engineers 3:2 on all FTSE 100 boards, though within the industry sector 28% of directorships were held by engineers compared with only 20% by accountants (chart 8.1 shows the numbers and proportions for all sectors).

When the sample was narrowed to the top or chief executives, qualified engineers outnumbered qualified accountants. Of the one hundred top executives, 17 proved to hold engineering qualifications, as opposed to 15 with accounting qualifications. Within the industry sector, the proportion of the top executives who were qualified engineers was as high as 41% (accountants made up only 9%), and even within the finance sector, where only one top executive was an engineer, no more than two were accountants (see chart 8.2 and table 8.2 for further details).

The Engineering Council up-dated the FTSE 100 top executive study in the middle of 2000, and found that 16 of the top executives of the FTSE 100 companies, including the new "dot com" companies, were engineers, compared to 17 who were accountants (see chart 8.2 and table 8.2). In the next analysis, the composition of the FTSE 100 being as at December 2001, it was found that 15 of the top executives were engineers, 10 were scientists and 20 were accountants (see chart 8.3 and table 8.3). This was up-dated in January 2004 by the Engineering and Technology Board; the research finding was very similar again and given the composition of the FTSE 100 at the 14th January 2004, 20 of the top executives were accounts, while 12 were scientists

Chart 8.1: Directorships of FTSE 100 companies by subject of director's qualification

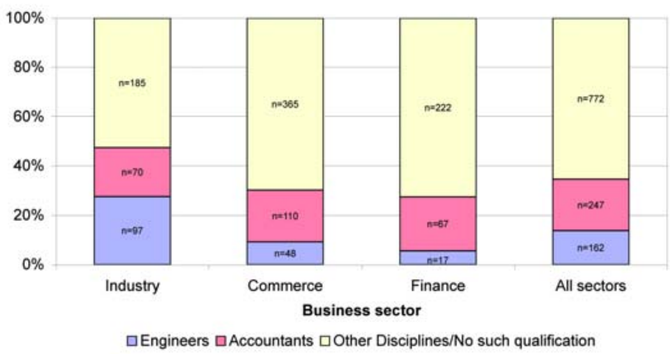
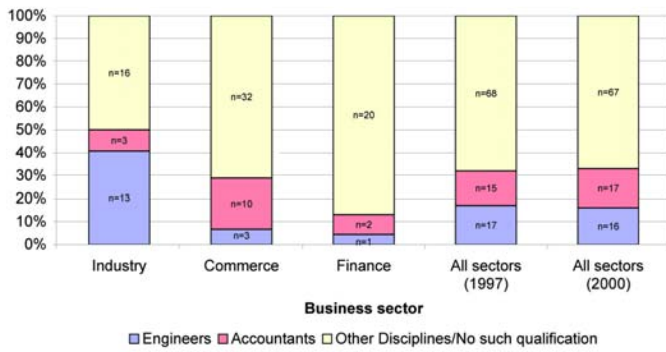


Chart 8.2: Top executives of FTSE 100 companies by subject of qualification, engineers



and 12 were engineers (see also chart 8.3 table 8.3). Also in June 2002, of the 121 Institutions of Higher Education in the UK, 52 had Vice-Chancellors or Principals with engineering or scientific qualifications. 17 of the 52 were professional engineers, representing 14% of the total. This was more than almost all other academic disciplines.

Engineering Council research, undertaken in 2000, has also found that among the companies in the dynamic venture capital industry in the UK, there were 121 qualified scientists and technologists from a total of 623 key managers such as Chief Executives, Managing Directors and Directors.[144] Of these 75 were graduate or postgraduate engineers.

8.2 Distribution of engineers throughout economy

Gratifying as it is to find engineers and scientists well-represented at the top of the business and academic world, it is still true to say that, until recently anyway, it is in manufacturing companies that engineers are most likely to have achieved a top position. The distribution of qualified engineer FTSE 100 directors between the sectors was: 60% in industry, 30% in commerce and 10% in finance. But it is important to note that the overall employment of engineering professionals differs markedly from this pattern.

Data on the employment of professional engineers, broadly defined, can be obtained from the Office for National Statistics' Labour Force Surveys, which are conducted quarterly. However the employment by industrial sector of those professional engineers who are registered with the Engineering Council is known from the Engineering Council Surveys of Professional Engineers and Technicians and the Engineering and Technology Board Survey of Registered Engineers (chart 8.4 and table 8.4). The most striking feature from the 2001 Survey is that only 38% of the profession are employed in manufacturing industry, with another 8.5% in construction. The remaining 54% are spread throughout all other sectors of the economy, including finance and business services (which includes engineering consultancy), transport and communications, electricity, gas and water supply, education and health and the public sector (though representation in agriculture and trade activities are below 1% of the total in employment). To summarise, 47% are employed in the production industries, which includes construction, and almost all the remainder are employed in the service sector. This chart, more than any other information available at present, clearly demonstrates the influence of the engineering profession on all aspects of our daily life, and, indeed, its importance in the development of our future. Similar data is obtained from earlier Engineering Council Surveys of Professional Engineers and Technicians and Engineering and Technology Board Surveys (see table 8.4) and from the Engineering Council (UK) 2002 Survey of Registered Engineers. Data obtained from the DTI in 2000 using the Office for National Statistics (ONS) Labour Force Survey count of engineering graduates (see table 8.5) lends support to the Engineering Council and Engineering and Technology Board 2003 Survey figures, as does anecdotal evidence. From financial analysis; to the design and maintenance of dealing desks in the City; to mobile telecommunications; to supermarket electronic point of sale (EPOS) systems, engineering underpins the modern economy. The media, leisure centres and healthcare facilities all depend on professional engineering.

The summer 2001 Labour Force Survey analysed the number of professional engineers (ONS defined) and showed a marginally higher proportion employed in the production industries. 19% were working in finance and business, of which 14% were found in engineering consulting, designing and contracting (see table 8.6).

8.3 National statistics and ‘the engineering profession’

Registration of all appropriately qualified engineers, as it is voluntary in the UK, is unlikely ever to be achieved.[145] For example registered Chartered Engineers and Incorporated Engineers may only represent about 25 to 40% of those likely to be eligible. This estimate is based on a calculation of all the Professional Engineers found in the Labour Force Survey[146] less IT strategy and planning professionals (SOC code 2131),and Software Engineers (SOC code 2132) - although some of these may be eligible - a net total of 425,137. The total number of Chartered Engineers and Incorporated Engineers at approximately the same time was 196,000 plus 49,000 respectively, a total of 245,000 or 58% of the estimated total of Labour Force Professional Engineers. If the number of Chartered Engineers working overseas and those retired are excluded, we arrive at the number estimated to be working in the UK of 158,400. Further if we make a similar adjustment to the Labour Force figures, as about 5% of these working engineers are non-UK nationals, then we arrive at a ratio of 158,400 over 404,000 which equals 39%. And using an estimate of the number of engineering and technology graduates working in 2000 of 493,900 (see table 8.10), we have a ratio of 158,400 over 493,900 which equals 32%; no adjustment has been made here for the small proportion of non-UK nationals who have an engineering or technology degree.

Surveys like the Engineering Council Survey of Professional Engineers and Technicians can tell us quite a lot about this sub-set of those working as engineers in the UK, namely the registrants. Most professional engineers take at least seven to ten years from leaving school to achieve a level of competence sufficient to attain full registration (see charts 8.5, 8.6 and 8.7 for a demonstration of this), so any short term mismatch between supply and demand or a longer term “latent” skills shortage can take a decade to correct. The recent tightening employment market and higher starting salaries for newly qualified engineering graduates are indicators of demand as are rising real salaries (that is salaries adjusted for the increase in inflation) over the period 1994 to 2000 for engineering and technology graduates.[147]

The two Government Statistical Service (or Office for National Statistics) classification coding systems used for the analysis of nationally-collected data – the Standard Occupational Classification (SOC2000) and the Standard Industrial Classification (SIC92) - both have their shortcomings, but they are the only national classifications that exist in the UK. And meaningful data at industry level is produced only within the framework of the industrial classification used and difficulties are encountered when trying to measure the economic activity brought about by engineers working elsewhere than the manufacturing engineering.[148] Frustration at this general state of affairs was reflected during 2001 in the report of a working group set up by the Hawley Review and Chaired by Sir Robert Malpas[149] to investigate the “Universe of Engineering”. At the end of Section Three of the report “The Universe of Engineering” it concluded that “without considerable research it is impossible to estimate the number of people who, in the course of their work, practice engineering”

Chart 8.3: Top executives of FTSE 100 companies by subject of qualification, engineers and scientists

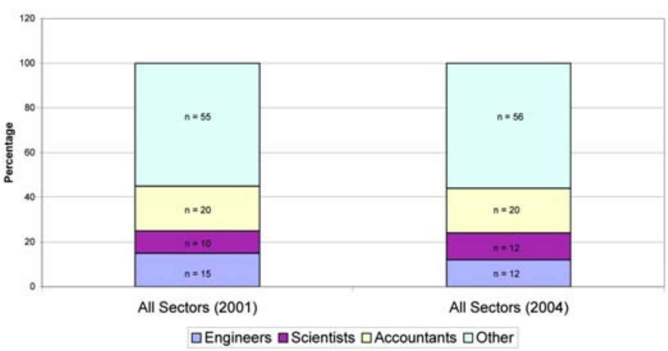


Chart 8.4: Employment of registered engineers by industrial sector in 2003 (Source: The Engineering and Technology Board)

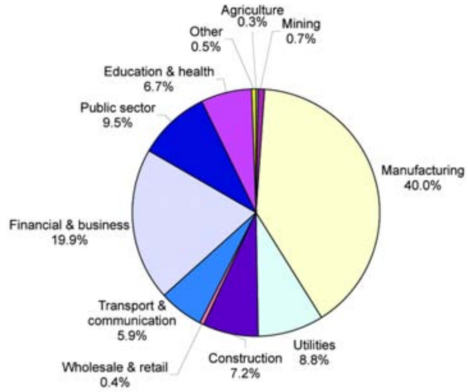


Chart 8.5: Age of New Registrants at Registration in 2002 & 2003 (Source: EC (UK))

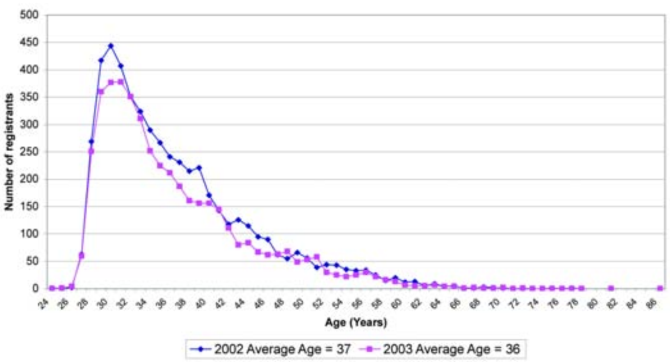
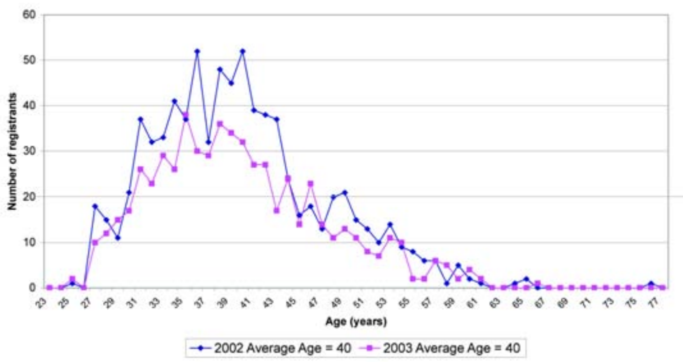


Chart 8.6: Age of New I Eng Registrants at Registration in 2002 & 2003 (Source: EC (UK))



However, in the summer of 2001, the Engineering Council obtained a large matrix of data analysing specific jobs by the SOC 2000 and by detailed SIC 1992, and table 8.7 contains figures as at spring 2001 of the "Malpas Universe" (or an approximation to it analysed by SOC 2000). The total is estimated to be 2.4 million and is similar to a figure to that found in the "Universe of Engineering Report" of "about 2,000,000 people in the UK who call themselves engineers". However the Report went on to state that "There are no reliable figures to estimate the numbers of people whose title does not include engineering but who practice engineering in the course of their work, scientists, technologists, metallurgists, computer programmers, and many more". This view may well be an exaggeration, but there are undoubtedly difficulties using official UK Labour Force Survey data sources.

For example, tables 8.8, 8.9 and 8.10 contain data taken from the ONS Labour Force Surveys from 1992 to 2000 for men and women with engineering and technology degrees analysed by two-digit Standard Occupational Classification (SIC1990) code. This data was in fact taken from a study prepared for the Department of Trade and Industry to investigate trends in the labour market for graduate scientists, engineers and technologists,[150] but this data is also found in the Engineering and Technology Board sponsored study published at about the same time.[151] To arrive at information relating to graduate engineers and technologists from such survey sources, use was made of data classified both by occupation or by subject studied for a degree to arrive at a definition of "graduate engineers and technologists". Thus according to this UK Labour Force Survey data the number of persons in employment holding a degree classified as "engineering/technology" rose to almost half a million by 2000. This represented 9.2 per cent of all degree holders in employment. But as the number of total degrees holders in employment grew from 3.5 million in 1992 to 5.4 million in 2000, the proportion holding a degree in an engineering or technology subject has declined steadily over this period. Other trends of note were that the number employed as engineers and technologists has fallen over the period, whilst the number employed as computer analysts and programmers, software engineers and computer engineers has more than compensated for this observed fall. Also of interest is that a significant number of persons holding engineering and technology degrees work in occupations that do not appear to relate directly to their area of qualification. But in part, this relates to their movement into managerial positions – in the two older age groups it can be clearly seen that the proportion classified as "Other Occupations – Code 99" is significantly higher than for the 21 – 29 age group. A separate analysis of the structure of these "other occupations" indicates the predominance of managerial jobs in this category and reflects the fact that graduates in engineering and technology, just like many other graduates, get promoted into middle and senior management or even directorial positions as they move into the higher age groupings. Finally the proportion of women with engineering and technology degrees has remained in the range 5 to 10 per cent over this period. Caution must be exercised in interpreting these figures too precisely due to the small sample upon which they are based.[152] Indeed "small sample size" is one of the main problems when using data from the Labour Force Survey as we are told that this can have the effect of producing fluctuations in the data due to the sampling error. It is therefore important to look at time series data to identify general patterns and trends. But estimates covering fewer than 10,000 people are likely to be unreliable since they are based on small samples of fewer than 30 people.

In 2001 the Institute of Employment Studies (IES) published a report entitled "Assessing the Supply and Demand for Scientists and Technologists in Europe".[153] It would have been useful to compare the data within Europe. However, one of the conclusions that the IES and the Research Centre for Education and the Labour Market (ROA) at the University of Maastricht came to, was that they were in fact unable to assess the demand and supply of scientists in Europe precisely because of a lack of statistical harmony at European level when dealing with the occupational classifications found in the various nation states; so the problems of using official data are compounded when looking at international sources. The report therefore focussed on the employment of research and development (R & D) professionals, with the aid of a questionnaire sent to employers of R & D personnel. A forecasting model was developed to track the flows entering and leaving the labour market for research scientists and engineers (RSEs) over the period 1997 to 2002, based on the data available up to 1997. The report concluded that, although the IES Survey of R & D Establishments did fill some gaps, other gaps had to be closed on the basis of assumptions and approximations. Finally the report stated that "It is therefore essential for any future modelling of the labour market for RSEs in the European Union, that the availability and quality of data on RSEs is improved".

Just after the IES published its report, the Chancellor of the Exchequer announced in his Budget Speech that Professor Sir Gareth Roberts was to lead an independent review of the supply of scientists and engineers in the UK. As noted above, the report of Sir Gareth Roberts Review was published in April 2002.[154]

Also the Engineering Council (UK) in 2002 examined data from Eurostat, the statistical arm of the European Union, using the international occupational classification ISCO-88. While detailed analysis needs to be undertaken, from an initial analysis of ISCO 214 "Professional Engineers and Architects", it would appear that when this data is normalised, as a fraction of the national workforce, then the UK at 2.4% (for all the quarters of 2000) has significantly more engineers and architects than Belgium (1.9%), Denmark (2.2%), Italy (0.8%) and Spain (1.3%) although Finland (2.8%) has more. However as Eurostat continues to improve the international comparability of the occupational data, detailed analysis of this data may well be possible now.

8.4 Engineering and Technology Board research published in 2003

The Engineering and Technology Board commenced a major research programme soon after it was set up in 2002 and some of it has yielded some useful data. For example data on technicians, widely defined to include not only engineering technicians but also those working with a science and technology qualification and in the electrical and vehicle trades is now available by main economic sector.[155] As Table 8.11 indicates only 16 per cent of technicians work in the manufacturing sector but 43% of all science and engineering technicians are found in manufacturing. 26 per cent were found in the public sector as were 24% of all science and engineering technicians and 23% of all IT service delivery occupations. 20% of these technicians were found in the distribution and hotels and catering sector and 71% of the electrical trades were found in this sector. A further 16 per cent of technicians were found in the business services sector and perhaps not surprisingly 39% of draught persons and building inspectors and 39% of IT service delivery occupations were found in

Chart 8.7: Age of New Eng Tech Registrants at Registration in 2002 & 2003
(Source: EC (UK))

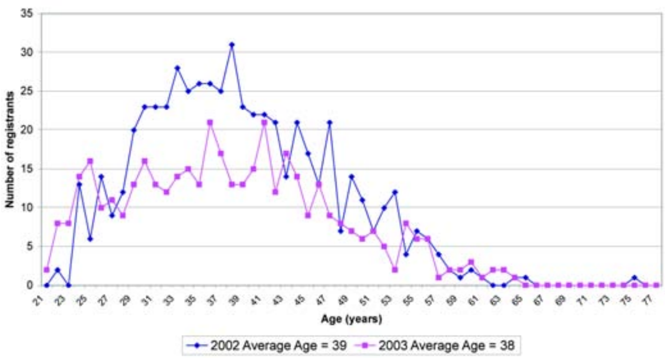


Chart 8.8: Females as a percentage of those with SET degree qualifications, in employment, 2002 (Source: ONS Labour Force Survey)

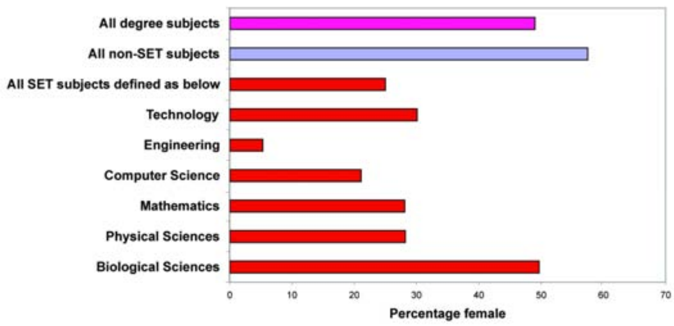


Chart 8.9: Percentage of females in SET professional occupations and other occupations, in employment, 2002 Source: ONS Labour Force Survey

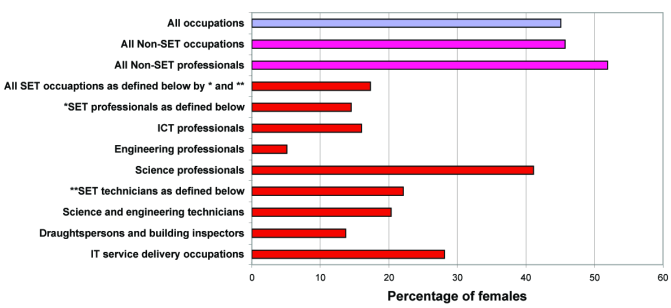
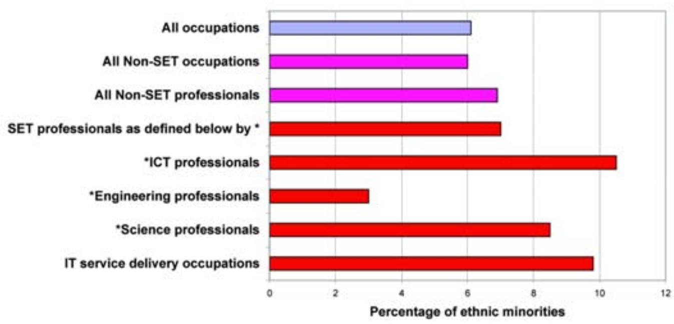


Chart 8.10: Percentage of ethnic minorities in SET occupations and other occupations, in employment, 2002 (Source: ONS Labour Force Survey)



this sector. The main conclusions to be drawn from the research were that technicians perform a range of roles and as group they exercise a wide variety of skills and the numbers entering these occupations is in persistent decline, while at the same time UK industry is experiencing real problems in both skills shortages and skills gaps at technician level across a wide range of occupational fields. Many begin their careers as apprentices or even graduates but they need to receive further training and career development if they are to keep their skills current and gain further competencies, especially in softer management skills. Better continuous professional development (CPD) provision would provide a way of unlocking any latent skills already present in the technician workforce.

Another major piece of research was published in 2003 by the Engineering and Technology Board.[156] In September 2002, the Engineering Council (UK) Board invited the Engineering and Technology Board to investigate whether the creation of a new register – tentatively called Chartered or Professional Technologist – would help promote careers in science, engineering and technology (SET). A Working Group was established including members of government, academic institutions and finance and industry. A research study was then commissioned by the Working Group, which was undertaken by the Institute for Employment Studies and various other market survey companies.
From a statistical point of view a wealth of data was made available for this report as it sought quantify the potential market for a new technologist type qualification, using the March to May 2002 Labour Market Survey. Examples of these are given in Table 8.12 and Chart 8.8, which analyses those with SET qualifications by gender, Table 8.13 and Chart 8.9, which analyses SET occupations by gender in Table 14 and Chart 8.10, which analyses SET occupations by ethnicity in 2002. The Background Data Annex to this report[157] yielded some interesting data on technologists and broadly three main approaches were adopted when defining technologists and these were by their occupation, by their qualifications either in terms of level of qualification and more generally by subject of qualification and finally by the sector that they work for. This annex can be found as an Annex to this publication; this data rich annex contains breakdowns of data by occupation and data by qualification by not only gender[158] and ethnicity but also by full and part-time work, type of degree, work-related training in the last 13 weeks, age band, region of work and key sector. The key sectors considered were high technology manufacturing sectors, medium high technology service sectors, knowledge intensive sectors and SET dependent sectors. The data by sector of employment is itself analysed by gender, ethnicity, full or pert-time working, level of qualification, work related training, age bands and region of employment.

8.5 Manufacturing, and the wider economy

As noted above, engineers and scientists worked across most major sectors of the economy. And while manufacturing as defined in the ONS National Accounts Bluebook contributed to 16.6% of GDP in 2002, the production and construction industries combined accounted for 27% of UK GDP. Construction is a major industry in the UK economy accounting for 6% of GDP and 7% of total employment. Following steady but moderate increases in construction activity, the expectation in 2001 was for further growth in 2002 and the forecasts at the time ranged from 1.4% (Cambridge Econometric) to 5.4% (Experian Business Strategies). In the event the actual increase during 2002 was 8 per cent and was therefore well above even the most optimistic expectations. This resulted in 2002 in a total construction output of £65 billion in 1995 prices; this was well above the level of about £51 billion in 1995 prices, recorded in 1993 at the bottom of the last construction industry recession.[159] In 2003 another good piece of research was published concerning the construction was published by nCRISP, the Construction Industry Research and Innovation Strategy Panel.[160] It pointed out that if you use the national account definition of construction, as did the CITB report above, then this may be regarded as a narrow definition of construction as it is consists of the on site construction of buildings and infrastructure by contractors. It therefore does not include the quarrying of construction raw materials, manufacture of building materials, the sale of construction products, on site assembly by non-contractors and the various associated professional services. And included in this broader definition is the DIY sector and in the informal or black economy, where of course data is extremely limited. Nevertheless it is possible that the size of construction according to this broader definition is double or nearly double that measured by the narrower ONS method and could therefore be about 10 per cent of GDP. This report also points out that total factor productivity levels in UK construction are on par with those observed in the USA and France, and higher than in Germany.[161] However the report also points out that the UK construction industry has a relatively poor R&D spend as a proportion of output. All this suggests that while technological change has been important in raising productivity in construction, the informal economy and its associated labour market flexibility may also have been an important factor leading to the relatively high levels of total factor productivity observed in UK construction industry.

And the latest figures for 2002 found in the ONS Balance of Payments Pinkbook show that 57% of our exports of goods and services consist of manufactured goods to the value of £156 billion; and that 40% of all our exports are accounted for by engineering manufacturing. Also the 2002 balance of payments figures also show that engineering consultancies earned a net surplus on the services account of £2.1 billion. This compares quite favourably with net surpluses in services for insurance (£6.2 billion), financial services (£10.5 billion) and computer and information services (£1.9 billion).

Finally, the issue of the contribution of science, engineering and technology (SET) to wealth creation and the economy is dealt with in more depth in the next Chapter particularly in sections 9.5 and 9.12. However, the overall view that seems to emerge, is that in a modern economy, science and technology are important to both the manufacturing sector and other industrial sectors, including those found in the service sector.

9 Technology, Education and Economic Growth

9.1 The Role of Engineers and Scientists in the Process of Economic Growth

A virtue of the modern age is the vast array of technological resources available to solve problems and create new products. For example the modern motorcar, although essentially a mechanical product made of steel, nowadays embraces leading edge technologies in electronics, computing, communications, materials and aerodynamics. Its design draws on medical science for improved safety, ergonomics for layout and socioeconometrics for market acceptability.

In the UK and in key competitor countries such as Germany, the USA and France, there are growing technical opportunities, offered by the increasing variety of ways that are available to solve an engineering problem. At the same time shorter manufacturing production cycles and the need for constant innovation have contributed to a substantial shift in the mix of skills demanded of highly qualified personnel, particularly in manufacturing.

However, this shift appears to be less well advanced in many industrial sectors in Britain. Research by the National Institute of Economic and Social Research, utilising the comparative analysis of economic performance, shows that the employment of well qualified scientists and engineers pays off in terms of competitiveness. This seems especially the case in high quality, high technology industries.[162 163 164] Thus the use of highly skilled engineers in the workforce can increase a company's profitability and the nation's productivity. And higher productivity is likely to lead to higher economic growth.

Other studies also show that where the UK loses out in terms of skill levels of engineers (and scientists) and in the associated innovative activity, then a loss of competitiveness occurs in terms of a loss of domestic market share, loss of international trade share and in lower productivity levels. Lower skill levels and innovative activity, particularly when found in the high technology and high growth industries, can adversely affect product quality and product variety;[165] and productivity and industry size.[166]

Hence studies of international competitiveness and skill levels do seem to demonstrate that parts of the British engineering industry may suffer from what has been referred to as a "latent" skills shortage over and above any skills gaps currently being perceived by employers.[167] In engineering and other industries where engineers work and where existing skills levels appear adequate to meet present business objectives, it must nevertheless always be questioned whether the product and training strategies associated with these objectives are sustainable into the medium and long term.

9.2 Economic Growth and Development

Before proceeding to consider the possible sources of economic growth and some related theories of economic growth, it is perhaps useful to consider the contours of world development over the long term.[168]

Over the past millennium, world population rose 22-fold. Per capita income increased 13-fold, world GDP nearly 300-fold. This contrasts sharply with the preceding millennium, when world population grew by only a sixth, and there was no advance in per capita income. From the year 1000 to 1820 the advance in per capita income was a slow crawl; the world average rose about 50 per cent. Most of the growth that occurred was absorbed by a fourfold increase in population. However, since 1820, world development has been much more dynamic. Per capita income has risen more than 8-fold, population more than 5-fold.

Per capita income is not the only indicator of welfare. Over the long run, there has been a dramatic increase in life expectancy. In the year 1000, the average infant could expect to live about 24 years. A third would die in the first year of life, and hunger and epidemic disease would ravage the survivors. There was an almost imperceptible rise up to 1820, mainly in Western Europe. Most of the improvement has occurred since then. Now the average infant in the world can expect to survive 66 years.

The growth process has been uneven in geographic distribution as well as time. The rise in life expectancy and income has been most rapid in Western Europe, North America, Australasia and Japan. By 1820, this group had forged ahead to an income level twice that of the rest of the world. By 1998, the gap was 7:1. Between the present world leader the United States of America and the poorest region of Africa the gap is now 20:1. This gap still appears to be widening. But divergence is not inexorable. In the past half century, resurgent Asian countries have demonstrated that a significant degree of catch-up is feasible. Nevertheless world economic growth has slowed quite a bit since 1973, except perhaps very recently, and the relative Asian advance has been offset by stagnation or retrogression elsewhere in the world.

9.3 Economic Growth Theory, Technological Change and Education

Economic growth theory[169] can be utilised to further understand the role of engineering and technology in the economy. Discussions today on the topic of economic growth and technological change usually start with the 1950's work of the American economist Robert Solow, the Nobel Laureate in Economics in 1987 for his contributions to the theory of economic growth, and now Institute Professor of Economics, Emeritus, at the Massachusetts Institute of Technology.[170] In Solow's model technical change and knowledge production were assumed to be independent of the inputs of physical capital and labour and to be freely available. Solow used a 40 year time series of US National Account data (for the non-farm private sector) to estimate the part of economic growth that could not be explained by the growth of capital and labour alone. His work suggested that just over 85% of economic growth could only be explained by this "exogenous" technical change.[171] One interesting logical conclusion of this type of model is that if technological know-how were universally available, in the long run all countries' economic growth rates and living standards would, under certain conditions, eventually converge and become more or less the same.[172]

Since the time of Solow's ground breaking work other models have been formulated, which usually come under the heading of "endogenous" models, where human capital (or knowledge) has also been explicitly introduced into the production function and where to varying degrees technological change is determined by the model. And while no general consensus has emerged so far on the precise approach to understanding what causes economic growth, several common threads are emerging. Firstly very few people believe that capital accumulation alone can account for the large increases in standards of living observed in the developed countries over the last 1 to 2 centuries. As Romer (1993)[173] has said:

"Our knowledge of economic history, of what production looked like 100 years ago, and of current events convinces us beyond any doubt that discovery, invention, and innovation are of overwhelming importance in economic growth and that the economic goods that come from these activities are different in a fundamental way from ordinary objects. We could produce statistical evidence suggesting that all growth came from capital accumulation with no room for anything called technological change. But we would not believe it".

Explicit consideration of technological change has, of course, ramifications both in terms of innovation and technology transfer.[174] Also the new theories of economic growth imply that government policies, either directly through taxes and subsidies or indirectly through the reform of the country's institutions, can have a stronger effect on growth than that predicted by the earlier traditional "neo-classical" growth models (of the Solow variety). Further, the cost of failing to exploit adequately the opportunities for technology transfer may be considerable. This suggests the importance of policies in areas such as skill acquisition and foreign direct investment (FDI) designed to reduce the "ideas gap" (in the "knowledge economy") and the "technology gap".[175] Clearly therefore the Engineering Council has played its part to enhance and promote economic growth through, for example, its role in raising standards for engineering in SARTOR and UK-SPEC (see section 4.6 above).

9.4 The Structuralist Approach

Finally, there is another approach to modelling economic growth, called the "Structuralist Approach".[176] Economic growth here is accepted as largely driven by technological change but it is assessed in the micro-economic context. Technological change is regarded as having a microstructure with changes in its individual components following a distinct trajectory, such as might be described by a logistic curve. According to this view, the growth process is largely driven by technological changes following a direct path. These in turn are strongly influenced by institutions and modes of organisational behaviour – so that "historical accidents", like the invention of the telegraph, or a transport technology such as the railroads, may have lasting impacts on the macro-structure as a whole. Understanding the growth process requires understanding the evolution of individual technologies, as well as the structure that links them together. Joseph Schumpeter argued, as others argue today, that growth is inextricably bound up with history and can only be adequately understood as part of a path-dependent, historical process. In particular Lispey and Bekar[177] argue that growth creating technological change occurs in large jumps causing what they term "deep structural adjustments"; and, very importantly that such changes cannot be captured by modelling technological changes as a series of continuous small shocks, as is evident in the neo-classical models discussed above. They suggest that periods of deep structural adjustment have certain common characteristics; that such periods can be identified in past history, for example by the invention of writing (4000 BC), bronze (2000 BC, the first great materials revolution), the printing press, the harnessing of water, wind and steam power, the invention of the railways; and that we are living through one such period today.

Lipsey and Bekar believe that the current period of technological change is possibly one of the deepest and most rapid structural adjustment of all in the last thousand years and which is driven by the current information and communications revolution and which has at its core the computer. Possibly equally important in its impact, is the current materials revolution.[178] New products and processes are being designed around new materials expressly created to make the products and processes functional. This is equally true of recent aircraft designs and new undersea methods of extracting mineral and fossil wealth. Indeed, new materials are seen as crucial to the continued expansion of many important growth sectors, including microelectronics, transportation, architecture, construction, energy systems, aerospace engineering and the production process in the automobile industry. As these structural adjustments occur, there is every reason to expect that the latent power of the new technologies will be increasingly reflected in productivity growth.[179]

There are some common strands, however, between the two approaches to growth economics. In both paradigms technological change is at least partly endogenous. However the structuralist approach does sometimes yield different policy implications to the traditional approach. A typical result is that successful innovation policies are likely to be those that work within and reinforce the existing facilitating structure. The latter include such factors at the firm level (as the geographical location of all production units), at industry level and those that are economy wide (such as social policy facilitating job mobility). Macro policies likely to be effective also influence the economy's infrastructure which in turn includes that part which "helps train humans – elementary schools, trade schools, universities and on-the-job training".[180] This aspect of the structuralist approach appears similar to the human capital concept found in the "endogenous growth models" of recent times, suggesting again the importance of a skilled labour force in a technologically driven "knowledge economy".

9.5 The contribution of engineering and manufacturing to the UK economy

Some of the ideas discussed above lie behind the long established complaint made by quite a few people in the manufacturing sector that their industries' true contribution to the wealth of the nation is not fully recognised. The public and media alike, often excited by the high rise in the price of shares of some high technology companies, or by the huge profits obtained through the successful discovery and exploitation of a new drug or oilfield, have had a tendency to ignore the less spectacular and less noticed benefits brought about by quieter and steadier sectors of the economy. When this is also combined with headlines about the fall of the number of employees and closing factories, then the overall impression can appear negative.

But does this paint a true picture? How should the contribution made to the economy by such diverse sectors as oil, banking and car manufacture be compared? One answer according to a scoreboard released for the first time in May 2002 by the Department of Trade and Industry's Innovation Unit, is to look at a measure called "value added (VA)", when analysing comp[any reports.[181] This concept will be familiar to anyone schooled in the principles of lean manufacturing or student or user of the national account statistics where it is used to calculate national output or Gross National Product (GDP). Put very simply it measures the difference between the price and quantity of the materials and services a company buys in and the price and quantity of the goods and services it sells on. The compliers of the scoreboard had to use a slightly different method of calculation since companies do not declare bought-in costs in their annual reports. Instead the scoreboard's authors have taken companies' declared profits before tax and added back employee costs, depreciation and amortisation.[182]

The DTI scoreboard seems to reveal goods news for anybody trying to prove that manufacturing is a vital source of wealth. In Europe, the companies in manufacturing account for 40.2 per cent of the total VA (of the top 300), while among the UK's top 500 companies manufacturing represents 31.6 per cent. In both the UK and Europe banks and the oil and gas sector top the charts, although their orders are reversed with banks contributing 16.3 per cent of Europe's VA and 10.6 per cent of the UK's, while the figures for oil and gas are 9.6 per cent for Europe and 14.7 per cent for the UK. Third place in Europe goes to the automotive sector with 8.5 per cent, while the lack of major UK-owned automotive firms means that same sector contributes 1.9 per cent to the UK figures.

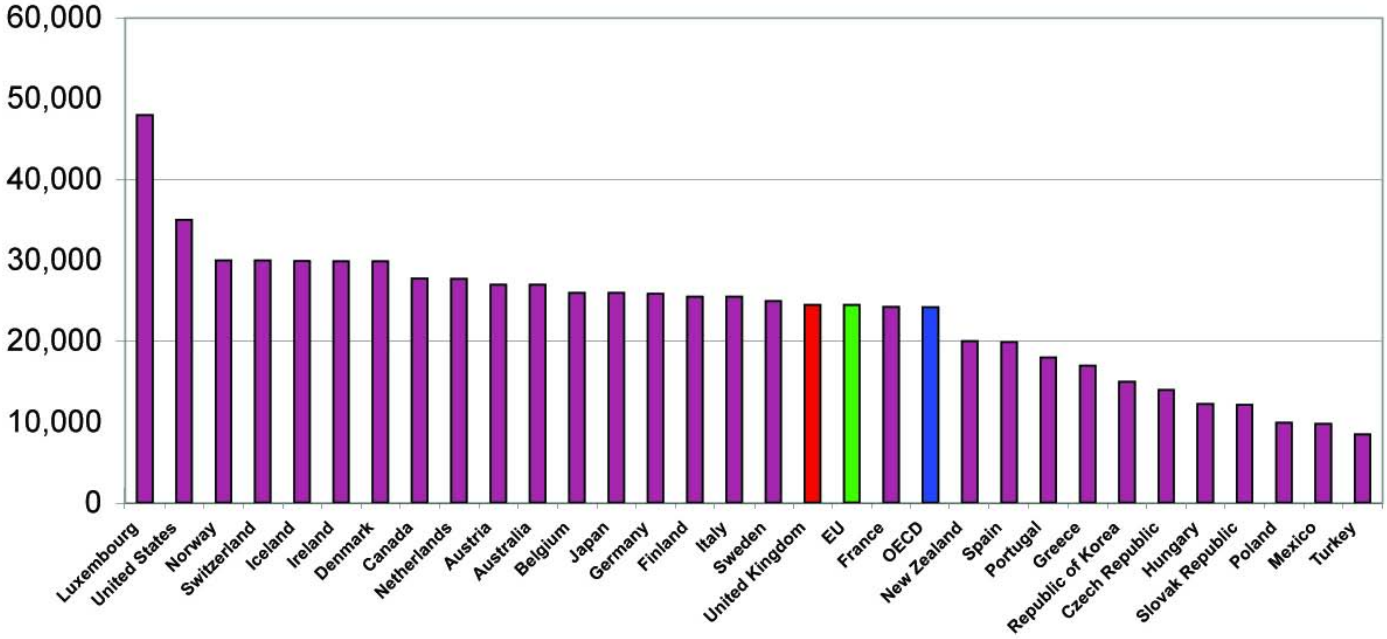
The second Value Added Scoreboard was published in April 2003[183], where a series of improvements in coverage were made including a doubling in the number of European companies from 300 to 600 and increasing the number of UK companies included from 500 to 800. The four largest sectors in Europe were banks (14.8%), telecommunications (7.8%), automotive (7.4%) and oil and gas (7.0%), while for the UK they were oil and gas (11.8%), banks (10.7%), support services (6.6%) and telecommunications (6.1%). The automotive, electricity and engineering sectors are proportionately larger in Europe than the UK, but oil and gas, food processing, retail and pharmaceuticals are larger in the UK.

Finally this method of demonstrating that an economy based entirely on retail and service activities would generate a lot less wealth than one including a wide range of resource-based and manufacturing activities, does not take account of technology spillovers or externalities. However if taken account of this may reveal an even greater effect on the creation of wealth or higher productivity but more economic research needs to be undertaken if this is to be recognised more widely.[184]

In 2003, the Institute of Physics (IoP) published a study that examined the importance of physics to the UK economy.[185] The IoP first examined "physics-based industry" in 1992 and this later report argued that the importance of physics to the UK economy has increased since then. What constitutes a physics based industry (PBI) was arrived at by combining survey work by the IoP and by looking carefully at both the Standard Industrial Classification (SIC) and the Standard Industrial Trade Classification (SITC). The initial starting point was the IoP survey of its members occupations; and members occupations were mapped with precise 3-digit SIC codes used in the compilation of the National Accounts. Next for further clarification the following three questions were asked. First if physics as a science did not exist, would the industry continue to operate or not? Secondly do the industry's manufacturing processes involve some form of physics based technology at a relatively sophisticated level? (On this line of argument the garden shears industry e.g. would not be classified as a PBI, but the industry that made the machine tools that produced the garden shears might well be included as a PBI). And thirdly, is the research and development (R&D) upon which the industry is based particularly slanted towards physics?

Following consultation with the statisticians at the Office of National Statistics, a list of 3 and 4-digit SIC codes were compiled (as found on page 36 of the report). A similar list of SITC codes were complied so as to analyse the international trade statistics (and as found on page 37). This enabled the report to report to conclude e.g. that by the year

Chart 9.1: GDP per head of population, US Dollars, Purchasing Power Parities, 2000; UK = $24,500 (Source: OECD)



2000, 43% of manufacturing industry employment in the UK was in PBIs. This represents 1.79 million people. Over the period 1992 to 2000, the number of people employed by PBIs remained more or less the same, while employment in manufacturing as a whole fell by about 10 per cent. Clearly if this is the case, then the importance of physics has increased in significance within manufacturing over this period. The report findings seem to be consistent with the view that manufacturing has been getting more "high tech" over time and that the workforce is becoming more skilled, in response to both supply and demand factors.

Also in 2003 a report for the Engineering and Physical Sciences Research Council[186] concluded by using detailed ONS Standard Occupational Classification and Standard Industrial Classification data that the engineering and physical sciences related sectors (EPS sectors) accounted for 30% of GDP, 40% of all investment and 75% of all industrial R&D. And perhaps reflecting the findings of the Institute of Physics report outlined above, this report also found that EPS sectors account for more than 70% of value added, employment and investment in plant and machinery in the manufacturing sector; EPS sectors are of even greater importance in terms of exports, accounting for mare than 85% of the total.

9.6 UK productivity, technology and innovation

The best single measure of prosperity, and overall living standards, is Gross Domestic Product (GDP) per head. And as Chart 9.1 shows this level was equivalent, at $24,500 per annum in 2000, to the EU average; and the UK is 17th in the list of countries found there. However, in recent years, there has been some evidence of a "catching-up" as the UK has had the fastest rate of growth per head from 1998 to 2001 in the G7 countries. And this appears to have been largely driven by a large increase in the number of people employed during the period 1999 to 2001; UK employment rates were well ahead of those of Canada, France, Germany and Italy.[187]

But the downside is that UK productivity continues to lag its major competitors. So despite a recent inferior labour market performance in Germany, Germany nevertheless continues to experience a higher average standard of living than does the UK (see Chart 9.1).

9.7 The measurement of productivity

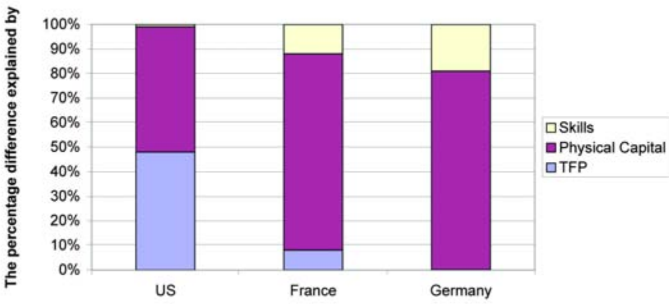
In measuring productivity for the aggregate economy, most researchers today deflate total GDP at market prices by the aggregate GDP purchasing power parity to compare output across countries in a common currency. The first two columns of Table 9.1 show estimates of relative GDP per person engaged in production and GDP per hour worked.[188] When labour input is measured as the number of persons employed, then the US emerges as having a pronounced lead over all three European countries and Japan; and the "productivity gap" with the UK is about 40 per cent. However considerably larger average annual hours worked in the US coupled with the greater incidence of multiple jobs in the US, has the effect of reducing the US lead when labour productivity in measured in GDP per hour worked; the "productivity gap" with the US reduces to about 25 per cent. An alternative calculation begins with GDP at the sector or industry level, measured at basic prices and then aggregates across all sectors. Conversion to a common currency uses either the most relevant purchasing power parities (PPPs) for the sector being considered, or for industries where PPPs are thought to be inappropriate, alternative measures of relative prices are used such as unit value ratios. The final column in Table 9.1 shows estimate on this basis. And these estimate are very close to those found in column two, also GDP per hour worked, and confirm statistically the productivity gap that the UK has with the US and in 2 of the remaining countries considered and not including Japan.

Recent analysis suggests that a range of factors account for this productivity gap.[189] Applying the techniques of growth accounting, the UK labour productivity gap versus other advanced economies can be further decomposed into the effects of three components: physical capital intensity, labour force skills, and total factor productivity (or the component of productivity that cannot reasonably be explained by the quality or quantity of factor inputs). Each of these components is not causal, strictly speaking, but can be seen as an intermediate indicator of many microeconomic attributes of an economy. Nevertheless, the exercise of decomposing provides clues about where to look for the sources of any competitiveness differences or deficiencies.[190] So as Chart 9.2 indicates for the total economy, a relatively low capital stock per worker seems to be a common factor in all the comparisons with the UK; but skills appear to be more of a problem in relation continental Europe than it does in the USA. However, total factor productivity (TFP), the residual left over when you have fully accounted for the input of capital and labour, appears to have a substantial role in accounting for the productivity gap between the US and the UK.[191] TFP catches a range of other factors, such as innovation, company organisation and economies of scale and calculations of this "residual" assume constant returns to scale in the long run with respect to both capital and labour inputs.[192] The excellent O'Mahony and de Boer study also looks at productivity comparisons between various industry sectors and although the conclusions are similar to those found at the aggregate level, for manufacturing the message is gloomier, where e.g. in terms of labour productivity the UK shows a particularly poor performance in manufacturing (see Table 9.2). The US lead over the UK is also large in agriculture, the distributive trades, the utilities, as well as in manufacturing and is also substantial in financial and business services. The gap is considerably smaller in construction and personal services and the two countries have about equal productivity in transport and communications. France leads the UK in a number of sectors with a significant labour productivity advantage in the distributive trades and manufacturing and a somewhat smaller lead in the utilities. The German productivity advantage over the UK is largely driven by a lead in manufacturing, the financial and business sector and personal services. The results show Britain leading all countries in mining and extraction but this seems largely due to the differences in the composition of the sector with the British industry mostly comprising oil and gas extraction. Chart 9.3 attempts to explain the productivity gap found in manufacturing only where the gap is greater than that found in other sectors and in the economy as a whole. When decomposition analysis is undertaken for manufacturing only, total factor productivity seems important in explaining the gap in Germany and France, as well as in the US, while lack of worker skills now accounts for 25% of the productivity gap with Germany.

9.8 Important drivers of total factor productivity (TFP)

Other important drivers of total factor productivity are generally thought to be innovation, enterprise and competitive markets; these will now be examined in turn. UK science and engineering is still world class. In terms of papers and citations per head, the UK is in the leading group along with Canada (see Chart 9.4). Further the UK science and engineering base is responsible for 4.5% of the world's spending on science, produces 8% of the world's scientific papers, receives 9% of citations and claims around 10% of internationally recognised science prizes. Also as the Roberts Review noted "Overall, the UK's supply of science and engineering graduates is strong compared to that in many other industrialised countries, with the UK having more science and engineering graduates as a percentage of 25 – 35 year olds than any other G7 country apart from France".[193]

Chart 9.2: Explaining or Decomposing the UK's Productivity Gap with the US, France and Germany, for the Total Economy, 1999 (Source: O'Mahony and de Boer, NIESR)



However, the record for knowledge transfer seems less successful. For example real R&D industry funded business spend per worker is not only low relative to other G7 countries but has been stable from 1990 to 2000; and France, US and Japan have recorded increases in real business R&D spend per worker over this period (see Chart 9.5). And if total R&D spend is examined as a proportion of GDP then while the UK invested more than the rest of the G7 in 1981, by 1999 the US, France, Germany and Japan all spent more on R&D as percentage of GDP. Furthermore as Chart 9.6 demonstrates, the UK was the only country to experience a significant decline in total R&D spending when it is expressed as a share of GDP compared to its key competitors over the period 1981 to 1999. Large increases in the level of R&D investment will now be required if the UK is to catch up and converge with the G7 leaders, whose R&D investment levels are also rising.

These trends in R&D spend could be worrying given that R&D is often regarded as an important determinant of long-term productivity growth. And a recent analysis by Crafts[194] has suggested that persistently low levels of R&D expenditure may account for over 90% of the TFP gap that exists with the USA. In a recently published paper, the National Institute of Economic and Social Research sought to address reasons why UK R&D intensity was relatively weak during the 1990's. Using a panel data model for 11 broad manufacturing industry groups over the period 1993 to 2000, they found that the main reasons or explanations for the comparatively low level R&D investment in the 1990's were weak output growth in the manufacturing sector, the declining level of government funding for private industry and the appreciation of the real effective exchange rate after 1996. Taken together these factors have outweighed the stimulus being offered by the decline in long-term interest rates during the 1990's, the growing share of R&D expenditure being undertaken by foreign-owned firms, the rising level of competition in product markets and the increase in skilled labour employed on R&D work during the latter half of the 1990's.

And patents are another area where the UK appears to under perform. Although care is needed in interpreting patent data, it seems clear that the UK substantially underperforms nearly all its major competitors in terms of the number of patents granted or filed per head of the population (see Charts 9.7 & 9.8). Within the EU, the UK's level of patenting is lower than that of Germany or France but higher than that of Italy (see Chart 9.8). But on a more positive note, although UK firms undertake less R&D as do their foreign counterparts (see paragraphs above), the UK is nevertheless an attractive location for foreign firms wishing to access UK scientific and engineering excellence. The UK for example has one of the highest shares of foreign business R&D as a proportion of total business R&D in the OECD.[195]

However, other indicators reveal weakness in the UK's innovation performance and this is reflected e.g. in the number and value of new products coming to market. Although UK service sector performance is above the EU average, in manufacturing new products account for about 25% of new sales, compared to over 40% in Germany. Also the proportion of UK businesses that have introduced novel products is below the EU average. Also analyses of information sources seem to show that UK firms give a low priority in exploiting the UK science and engineering base (SEB). More worryingly, an initial study of comparable results from the Community and Innovation Survey (CIS) suggests that UK firms are becoming less likely to access the SEB for information. For example the CIS found that the proportion of firms in the UK using universities or higher education institutions for information fell from 43% in 1996 to 30% in 2000. And the most common source of innovation information was within the enterprise and UK firms seem to be learning less from their competitors.[196] Also a major finding in the 2003 report by Professor Michael Porter and Christine Ketels in their report "UK Competitiveness: moving to the next stage" was that "Current levels of innovation are insufficient to drive UK productivity growth and close the UK productivity gap versus key competitors".[197] And the Lambert Review published in 2003[198] reviewed the links between business and industry and business-industry collaboration. The general picture painted of business-university collaboration by this report was that while a good many positive changes had been made in the last 10 years or so, much remained to be done. The main challenge for the UK was thought to be not about how to increase the supply of commercial ideas for the universities into business. Instead the main question and problem was said to be about how to raise the overall level of demand by business for research from all sources. Finally all this was put together by the DTI in the Innovation Report "Competing in the Global Economy: the innovation challenge"[199], where there is also found a series of recommendations together with ideas and statements as to how these recommendations will be best achieved.

9.9 Enterprise and competition

Enterprise involves the identification and exploitation of new business opportunities. It plays an important role in economic growth through fostering innovation and investment. The entry, exit, growth and decline of firms are crucial mechanisms through which economies allocate scarce resources to their most productive applications. And in recent years there is some evidence to suggest that the expansion of ICT in recent years has increased the economic importance of entrepreneurship in driving economic growth. New technologies e.g. are able to lower the costs involved with information gathering, communications and making transactions, thus reducing the commercial advantages of large incumbent firms. This offers opportunities for new, innovative start-ups that can improve products and processes.

Measuring entrepreneurship is difficult but one recent attempt to do this was made by the Global Enterprise Monitor (GEM). The GEM defines the participation rate in entrepreneurial activity to be then proportion of individuals in the process of starting a new business, or the proportion who are owner-mangers of businesses that are less than 3 and a _ years old. On this measure the level of entrepreneurship is higher than in Japan, broadly comparable with Germany but much lower than in Italy, Canada and the USA (Chart 9.9). So these entrepreneurship

Chart 9.3: Explaining or Decomposing the UK's Producutivity Gap with the US, France and Germany, for Manufacturing, 1999 (Source: O.Mahony and de Boer, NIESR)

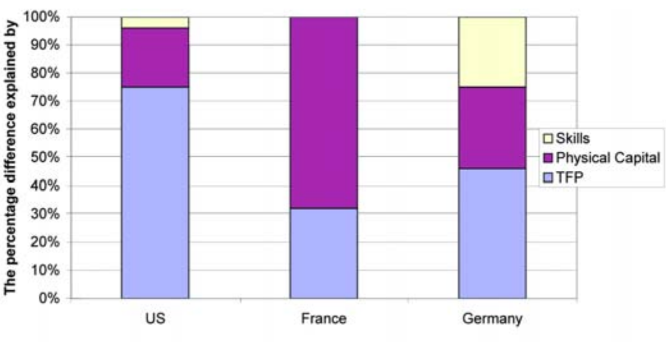


Chart 9.4: Papers and citations per head of population G7 comparison, 1995 to 2000 (Source: OST)

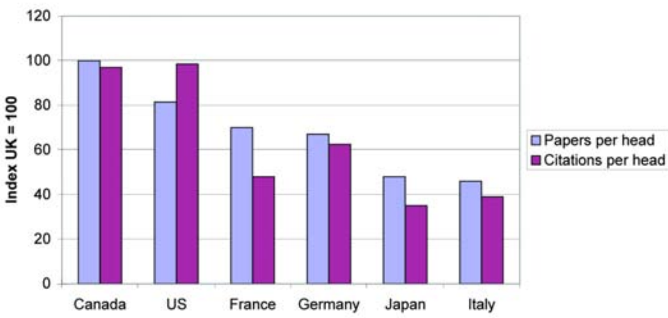


Chart 9.5: Industry-funded business enterprise R&D (BERD) real expenditure per worker (Source: OECD)

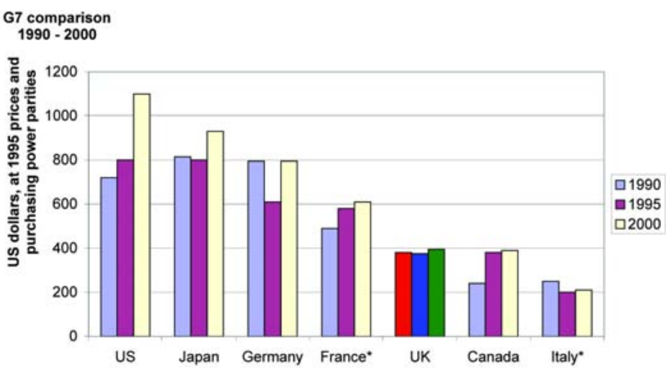


Chart 9.6: Growth in R&D spending expressed as a share of GDP, from 1981 to 1999 (Source: OECD)

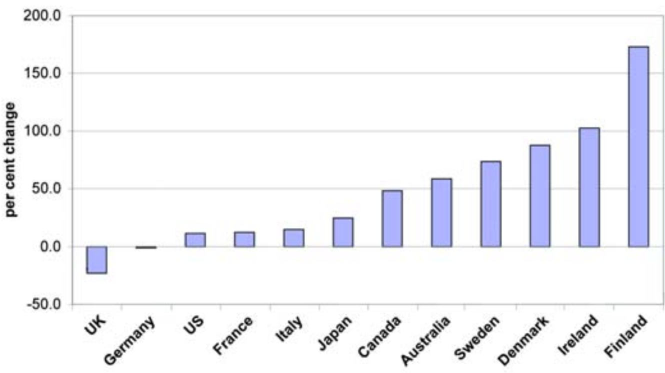


Chart 9.7: US Patents Granted, 2000 (Source: US Patent and Trademark Office

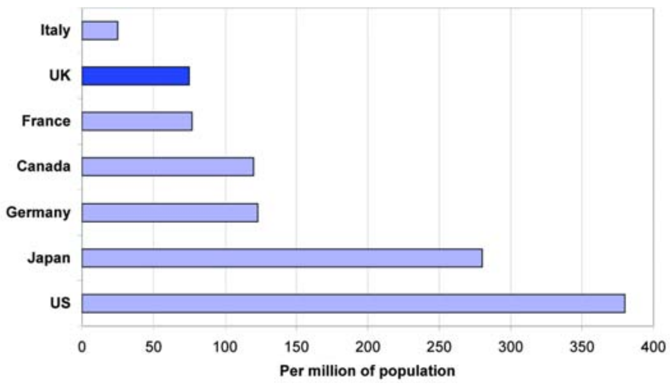


Chart 9.8: EU Patent Applications, 2000 (Source: US Patent and Trademark Office

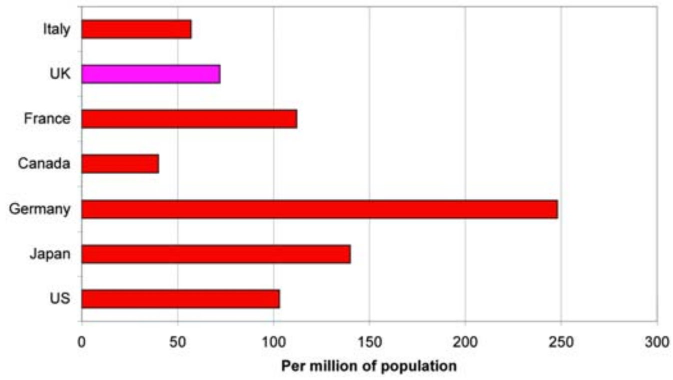


Chart 9.9: Entreprenuership rates (Source: Global Enterprenuership Monitor

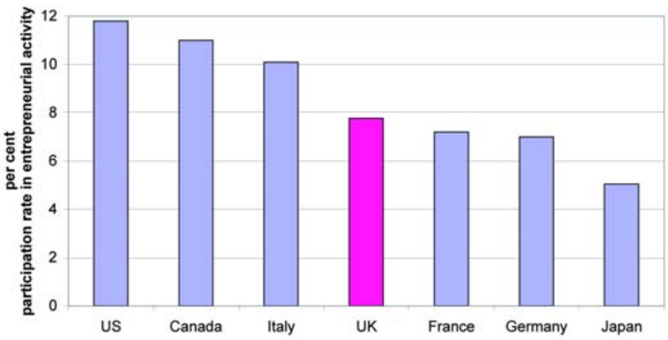
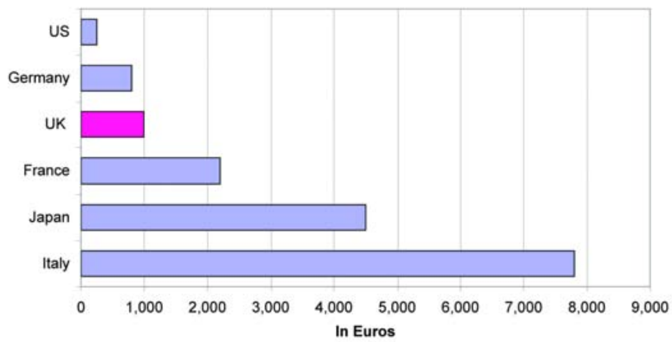


Chart 9.10: Costs in setting up a business (euros) Source: OECD)



rates are moderate at best and they exist despite some important advantages in the UK business and regulatory environment. Aspects of the business environment can, of course, act to discourage entrepreneurship and such aspects include tax, regulation and administrative burdens. However, in the UK both the cost and time taken to start a new firm are below the average for the UK's major competitors (see Chart 9.10 and 9.11).

An important factor that may be limiting entrepreneurship in the UK is the low rate of female participation. The GEM also shows that the proportion of women in the UK involved is less than one third of the participation rate for men and this rate compares badly across all 20 GEM countries. These findings are also supported by an OECD study which found that the UK had the third lowest female entrepreneurship participation rate amongst a sample of 15 highly developed economies. And countries such as the USA, Canada, Australia and New Zealand, which score highly on an overall measure of entrepreneurship, also have high rates of female entrepreneurial participation.

Access to finance is also important to would-be entrepreneurs and while it is true that for many established companies retained profits are an important source if funds for investment, stand-up and early stage businesses do not often not generate enough profit so they have to rely on external finance. Bank and trade finance are the most important sources of finance for the majority of small firms. However, in cases where a firm is perceived to be of high risk, or when lead times are very long, equity finance is usually seen as more suitable. And equity finance is particularly appropriate in the case of high risk and high growth firms as this method of finance avoids the cash flow problems associated with debt finance; it also allows the finance provider a share of any subsequent upside in the share price to compensate for the risk involved. And the main sources of equity finance range from informal sources through family and friends and "business angels" to formal venture capital which is some times referred to as private equity. Informal finance dominates as the GEM indicated that in a recent year 82% of equity finance for new and nascent firms came form informal sources. However, formal venture capital still has a key role to play in enabling entrepreneurship to flourish and it seems that the UK enjoys a relatively strong position in venture capital provision. Chart 9.12 shows e.g. that the UK venture capital industry is one of the largest in Europe in relation to GDP; it also accounts for 28% of all European venture capital, being the largest absolutely. This is an important strength in the UK, for while the amounts are not as large as those accounted for by informal investment, evidence seems to indicate that companies which are backed by venture capital tend to grow very quickly indeed and generate significant amounts of employment.[200] However, very recent data from the OECD[201] shows that European countries generally trail significantly behind the North American countries of the USA and Canada; although the UK is ranked higher than nearly every European country when the rankings are based on the sum of early stage and expansion investment.

9.10 Trade and productivity

Finally the framework within which businesses consumers and employers interact is central to productivity and competitiveness and any successful framework must aim to secure vigorous competition between companies. Competition can raise productivity both now and in the future. It raises productivity now by ensuring that resources are allocated to those sectors and companies that are most productive and by forcing them to maintain the lowest possible production costs. Competition can raise productivity in the future by encouraging companies to produce new or better products and ways of producing them; if they fail to innovate then there is a chance that one of their competitors will do so. Conversely, on absence of competition enables incumbent firms to block new entrants, denying consumers choice and hindering innovation. And as measured by total exports and imports as a percentage of output and by the value of foreign investment expressed as a percentage of GDP[202], the UK remains a relatively open economy. And as discussed above, openness brings a number of productivity gains and empirical evidence suggests that international openness has raised economic growth in the UK and other European economies.[203]

9.11 European Monetary Union (EMU) and trade

In the context of the UK government's "fifth-test", a number of studies were published in June 2003 by HM Treasury that dealt with the likely effects of a currency union on trade and hence in turn on productivity and economic growth.[204] Good theoretical arguments are presented for expecting that the adoption of a common currency will lead to increased trade among the members of a single currency. The key mechanisms are: the reduction in exchange rate uncertainty; lower transaction costs; and wider benefits, in particular through greater price transparency, greater specialisation and enhanced competition. This is the first component of the argument, the second being that higher trade then leads to higher output (than would otherwise have been the case).

However the conclusion that the Treasury economists reach is not unfortunately empirically precise. For example UK trade with the eurozone, now close to 30% of GDP, may rise to anywhere between just over 30% and about 45%. And the impact of this on GDP, is in turn, put at between 1/3% and 2/3% of GDP for each percentage point increase in trade. This gives an estimated impact over a 30 year period of between a 1/2 per cent and 10 per cent of GDP. Thus the observed gap in productivity between the US and UK would only be closed by the adoption of the single European currency, the Euro, if the higher estimates were correct.

9.12 Current Research into Wealth Creation by the SET Community

In response to the lack of understanding of the precise economic effects of science and technology, research commenced in 2003 with the ultimate aim of quantifying the wealth created by the SET community. To drive this research project, the Engineering and Technology Board (ETB) brought together a working group comprising of the ETB, the Engineering and Physical Sciences Research Council, the Royal Academy of Engineering, the Royal Society and the Department of Trade and Industry. The group was formed to oversee the initial desk research phase of the project and a professional research group was commissioned to carry out this work. This exploratory work was completed in 2003 and further research was then commissioned to find out what the contribution of SET occupations is to the current level of economic activity. The study quantified the contribution of technological change and SET labour inputs to the level of and change in economic activity; or in other words the contribution of science, engineering and technology to the level of economic activity and to economic growth in the UK and some competitor countries. London Economics undertook this research work and their professional economists' utilised growth accounting techniques to calculate the contribution of SET and technology to economic growth and the growth of labour productivity. One finding of the report[205] is that in 2002, the high SET-intensive sectors of the economy produced £252.3 billion, which was 27.3% of total value added in 2002. Another major finding is that the high SET-intensive sectors contributed towards 27.1% of the total change in labour productivity over the period examined, which was 1993 to 2000; and that the absolute contribution of SET-intensive sectors to UK economic growth during the period 1993 to 200 was 0.5 percentage points per annum, higher than in Germany and Japan but lower than in the USA and France; science and technology are key drivers of productivity and economic growth. Other major findings were that the SET community generated more than £77.5 billion of value added in 2002, or 8.4% of the total UK value added in 2002; financial services, property and business support was the sector where the amount of GDP generated by the SET community was the highest, ahead of manufacturing; SET professionals generated the highest share of sectoral value added ion the construction sector; and 61% of the value added generated by SET skills was generated outside the SET-intensive sectors. Finally the report also looked at the contribution of SET-intensive sectors to the economic growth and productivity growth of other developed economies. Here the report found that as the SET-intensive sectors in the UK still account for a smaller fraction of total output growth (i.e. economic growth) and labour productivity growth than in France, Germany (only productivity), Japan and the US, there could be scope for the entire UK economy to grow faster and become more productive by improving the performance of these sectors.

London Economics used similar techniques in a report published in 2003, which attempted to show the effects of investment in ICT on the growth rate of output in recent years in the UK.[206]

Chart 9.11: Delays in setting up a business (weeks) Source: OECD)

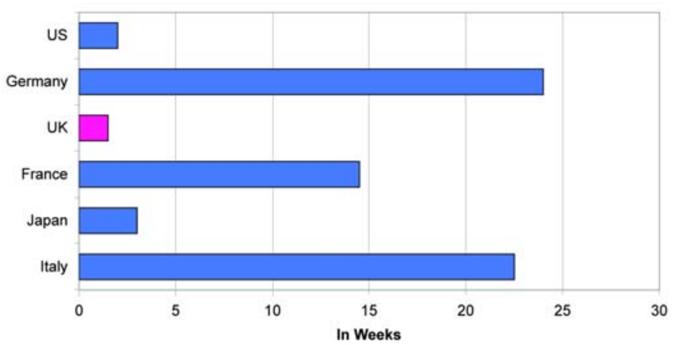
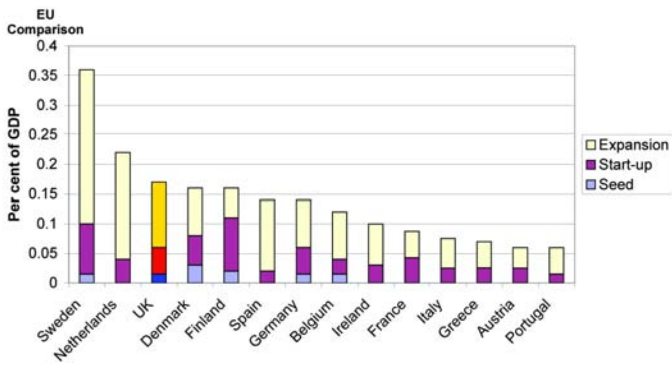


Chart 9.12: Venture Capital Investment
(Source: European Private Equity and Venture Capital Association)



TABLES

Tables Section 1.
Perceptions of engineering and science

Table 1.1: When you have finished your education, which two of the following jobs, if any, would be your preferred choice? (%)

(All answers above 5%)	Male	Female	Total
Professional sportsperson	27	8	18 (16)
Lawyer	14	20	17 (16)
Vet	8	21	15 (14)
Army/Navy	22	6	14 (14)
Teacher	6	20	13 (12)
Accountant	11	10	11 (9)
Hotel manager	8	13	10 (9)
Policeman	11	6	9 (9)
Professional engineer	14 (13)	1 (0.5)	8 (7)
Scientist	9	4	7
Nurse	1	14	7 (7)
Construction professional	9	3	6
Fire brigade	9	2	6
Social worker	1	10	6
Any engineering	17	1	9
None of these	11	17	14

Source: MORI/EMTA: Views of Engineering as a Career, 1998, 2001
Note: 2001 figures are in given brackets, and in 2001 a male/female split was not published for all job categories.

Table 1.2: How likely or unlikely are you to consider a career in engineering? (%)

	Male	Female	Total
Very likely	10 (9)	2 (1)	6 (6)
Fairly likely	17 (15)	3 (3)	10 (9)
Neither likely nor unlikely	18 (17)	8 (7)	13 (12)
Fairly unlikely	19 (17)	14 (14)	17 (16)
Very unlikely	30 (32)	68 (67)	49 (49)
Don't know	5 (9)	3 (8)	4 (8)

Source: MORI/EMTA: Views of Engineering as a Career, 1998, 2001
Note: 2001 figures are given in brackets

Table 1.3: How much do you agree or disagree with the following statements about engineering? (%)

	Male		Female	
	Agree	Disagree	Agree	Disagree
It's boring	31 (26)	33 (36)	50 (47)	11 (11)
Good wages/salary	45 (41)	14 (13)	28 (25)	15 (12)
Dirty working environment	55 (51)	12 (13)	61 (57)	8 (9)
Interesting work	57 (54)	13 16)	28 (27)	28 (28)
Working in factories	38	19	33	18
Need to be clever to do engineering	52	16	35	20
Secure job	37	20	22	23
Working in teams	59	7	48	6
A job mainly for men	46	24	36	40

Source: MORI/EMTA: Views of Engineering as a Career, 1998, 2001
Note: 2001 figures, where available, are given in brackets

Table 1.4: Please state the main reason why you took up engineering as a career (%

Influence of family or friends	13.0 (11.9)
Desire to help society	1.6 (1.5)
Desire to be creative/enjoyment of problem solving	42.5 (41.7)
Desire for a career change	1.2 (1.0)
Good at maths and sciences	24.9 (25.7)
Financial rewards available	0.7 (0.8)
Good employment prospects	10.2 (11.1)
Good career development opportunities	5.8 (6.3)

Source: The Engineering Council's 2001 Survey of Registered Engineers
Note: 1999 figures are given in brackets

Table 1.5: Would you recommend engineering as a career (%):

	To an young man	To a young woman
Yes	71.1 (67.4)	65.8 (61.6)
No	22.1 (24.6)	25.4 (28.8)
Don't know	6.8 (8.0)	8.8 (9.7)

Source: The Engineering Council's 2001 Survey of Registered Engineers
Note: 1999 figures are in brackets

Table 1.6: Please indicate the main reason why you would recommend engineering as a career (% those who said they would recommend it):

	To a young man	To a young woman
Challenge	55.1 (51.9)	56.2 (54.2)
Excitement	3.1 (2.9)	2.8 (2.9)
Pay	1.7 (1.6)	1.7 (2.0)
Satisfaction	39.6 (43.1)	38.0 (39.8)
Status	0.5 (0.5)	1.3 (1.0)

Source: The Engineering Council's 2001 Survey of Registered Engineers
Note: 1999 figures are in brackets

Table 1.7: Attitudes to engineering as a career.

Question: "How would you rate Professional Engineering as a career for a young person?

1978	% age for a man	% age for a woman
Very good career	60%	25%
Good career	33%	31%
Neither good nor poor career	4%	16%
Poor career	1%	20%
Very poor career	-	5%
Don't know	2%	3%

Note: The above response was almost identical from both male and female respondents
Source: Finniston, HMSO, January 1980.

Question: "Whether a career in science/engineering is considered to be a good choice?

2000	% All	% Male	% Female
Yes	74%	75%	72%
No	4%	5%	3%
Don't know	22%	20%	24%
Not stated	-	-	-

Source: British Attitude to Science, Engineering and Technology Survey, 2000

Table 1.8: Words to describe engineers

	Percent of all respondents		
All respondents 2000	Total	Male	Female
A Intelligent	54%	55%	54%
B Logical	36%	37%	35%
C Methodological	32%	33%	30%
D Male/Mostly male	31%	30%	31%
E Responsible	27%	28%	26%
F Rational/Logical	26%	27%	25%
G Enquiring	23%	26%	21%
H Largely funded by industry	21%	24%	19%
I Objective	16%	19%	14%
J Independent	13%	16%	10%
K Friendly	11%	10%	11%
L Socially responsible	11%	11%	11%
M Honest	10%	11%	9%

Source: British Attitude to Science, Engineering and Technology Survey, 2000

Tables Section 2.
Secondary education

Table 2.1: GCSEs achieved in Mathematics (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	11,350	12,589	14,418	14,522	14,841	16,194	19,176	19,936	25,959	22,713
A	49,231	43,235	44,534	48,827	51,502	51,885	54,799	54,103	58,417	59,280	61,234
B	59,769	101,030	90,592	99,741	99,962	105,666	111,762	113,685	120,054	124,746	122,485
C	154,553	140,895	156,798	162,095	159,162	144,611	147,253	150,667	155,210	155,297	154,073
Other	305,706	344,098	373,932	370,328	361,834	365,145	361,818	347,219	350,631	345,977	356,592
Total	569,259	640,608	678,445	695,409	686,982	682,148	691,826	684,850	704,248	710,895	717,097

Source: Joint Council for General Qualifications. Note: 2003 figures are final.

Table 2.2: GCSEs achieved in Physics (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	4,793	5,650	6,185	6,101	7,218	8,514	8,031	8,154	8,664	8,901
A	15,362	10,172	9,287	10,287	10,226	11,179	11,413	12,140	12,285	12,239	12,768
B	13,813	11,538	13,506	14,503	13,218	11,374	11,334	11,439	11,387	10,791	11,239
C	15,329	13,117	8,934	8,733	9,250	9,678	9,665	9,478	9,566	9,535	9,785
Other	20,772	13,883	6,462	6,744	6,183	6,075	5,865	5,603	5,282	5,308	5,336
Total	65,276	53,503	43,839	46,452	44,978	45,524	46,791	46,691	46,674	46,537	48,029

Source: Joint Council for General Qualifications. Note: 2003 figures are final.

Table 2.3: GCSEs achieved in Science: Double Award (all boards, UK candidates)

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	23,903	33,906	31,608	35,300	34,410	37,459	38,728	41,684	42,588	41,878
A	57,083	58,540	65,464	71,309	70,654	76,939	76,311	80,597	83,508	84,099	89,419
B	74,825	155,915	173,599	179,260	177,682	126,113	126,298	124,559	130,929	134,370	139,088
C	139,614	160,803	201,625	208,733	208,177	258,794	267,092	276,332	294,087	296,089	306,369
Other	335,475	479,593	523,081	523,361	523,760	522,652	533,367	526,496	538,519	537,964	537,544
Total	606,997	878,754	997,675	1,014,271	1,015,573	1,018,908	1,040,527	1,046,711	1,088,727	1,095,110	1,039,150

Source: Joint Council for General Qualifications. Note: Science: Double Award counts as two GCSE entries. These entries, therefore, are counted twice, both in the subject and in the overall figures. Note: 2003 figures are final.

Table 2.4: GCSEs achieved in Chemistry (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	3,904	4,831	5,396	6,281	6,228	7,235	7,414	7,604	7,886	8,898
A	14,143	10,724	9,443	10,699	10,040	12,200	12,170	12,342	12,833	12,737	12,412
B	15,638	12,754	12,474	13,890	13,433	12,478	12,175	12,060	11,708	11,608	11,733
C	13,270	11,661	10,190	10,417	10,040	9,504	9,823	9.761	9,718	9,708	10,412
Other	19,250	13,014	6,984	6,522	6,053	5,674	5,782	5,350	5,141	5,168	5,421
Total	62,302	52,056	43,921	46,924	45,846	46,084	47,185	46,297	47,004	47,107	48,876

Source: Joint Council for General Qualifications. Note: 2003 figures are final.

Table 2.5: GCSEs achieved in Design and Technology (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	4,156	4,882	4,930	4,954	8,970	9,768	10,934	10,897	11,665	14,170
A	18,834	15,378	24,787	20,543	20,339	36,890	41,536	43,316	45,993	46,254	47,677
B	28,046	29,302	58,212	44,920	43,286	53,874	60,541	63,502	65,492	65,997	66,518
C	38,282	39,277	78,117	55,329	53,456	89,129	95,624	98,828	102,876	103,471	107,627
Other	119,553	119,700	209,563	148,182	138,724	194,902	201,493	203,964	207,455	201,251	199,997
Total	204,715	207,813	375,561	273,904	260,759	383,765	408,962	420,544	432,713	428,638	435,989

Source: Joint Council for General Qualifications. Note: 2003 figures are final.

Table 2.6: GCSEs achieved in Information Technology (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	1,584	978	1,736	1,799	2,952	3,941	4,932	5,644	6,119	5,243
A	5,916	4,753	3,359	5,484	6,786	8,377	9,386	10,357	13,107	14,082	11,546
B	8,782	8,569	7,942	11,887	14,756	12,845	13,718	15,289	18,366	18,958	15,095
C	12,168	11,507	9,729	15,750	17,254	20,584	21,895	25,646	28,867	30,358	22,384
Other	26,291	23,727	21,061	28,035	29,971	35,026	38,047	42,415	47,428	47,760	38,321
Total	53,157	50,140	43,069	62,892	70,566	79,784	86,987	98,639	113,412	117,277	92,589

Source: 1993 to 1997 figures are taken from the QCA web site for Information Technology and Computer Studies; figures after this are from the Joint Council for General Qualifications and due to definitional changes the earlier QCA figures may not be strictly comparable with the Joint Council data. Note: 2003 figures are final.

Table 2.7: GCSEs achieved in Biology (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A*	-	3,459	4,067	5,382	5,195	5,559	6,724	6,781	7,829	7,840	8,205
A	15,199	11,955	11,495	11,926	12,337	13,050	12,694	13,332	12,918	13,263	13,636
B	16,847	15,790	15,916	16,635	16,056	13,928	14,143	13,792	13,590	13,785	13,561
C	23,164	17,745	12,497	12,354	11,806	13,050	12,636	12,757	12,024	11,672	12,407
Other	36,349	26,241	14,972	14,861	13,635	12,934	11,766	10,803	9,563	9.083	9,956
Total	91,559	75,190	58,947	61,158	59,029	58,521	57,963	57,465	55,924	55,643	57,765

Source: Joint Council for General Qualifications. Note: 2003 figures are final.

Table 2.8: GCE A-levels achieved in Mathematics (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	15,940	16,188	17,520	18,314	19,027	19,955	20,003	19,646	19,893	21,229	22,173
B	11,097	11,496	11,648	12,953	13,862	13,317	13,221	12,806	12,548	10,419	11,157
C	10,134	10,448	10,527	11,281	11,753	11,463	11,508	11,054	10,706	8,245	8.632
D	9,043	9,039	8,914	9,330	9,609	9,406	9,453	9,257	9,217	6,181	6,222
E	7,411	6,997	6,642	7,223	7,056	7,191	7,330	6,644	7,052	4,143	4,119
N & U	11,298	9,359	8,176	7,150	6,803	6,916	6,987	6,429	6,475	2,440	2,364
Total	64,923	63,527	63,427	66,251	68,110	68,248	68,502	65,836	65,891	52,657	54,667

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished. Note: 2003 figures are final.

Table 2.9: GCE A-levels achieved in Further Mathematics (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	1,667	1,551	1,464	1,731	1,763	1,889	2,726	2,726	2,822	3,145	3,268
B	781	648	664	748	738	772	1,089	1,007	1.008	777	867
C	522	444	447	513	541	519	740	694	666	466	509
D	365	340	325	342	332	370	459	468	463	278	351
E	282	248	234	243	243	215	292	269	264	153	249
N & U	306	270	254	220	166	174	232	198	215	76	93
Total	3,923	3,501	3,388	3,797	3,783	3,939	5,538	5,362	5,438	4,895	5,337

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.

Table 2.10: GCE A-levels achieved in Physics (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	6,329	6,511	7,367	6,838	7,186	7,745	8,253	7,979	7,740	8,559	8,396
B	6,038	5,616	5,740	6,330	7,173	7,109	6,777	6,419	6,150	6,318	6,218
C	6,178	5,992	5,863	5,893	6,120	6,270	6,307	5,884	5,658	5,729	5,411
D	6,444	5,988	5,561	5,148	5,142	5,161	5,065	4,749	4,506	4,846	4,604
E	5,474	5,433	4,664	4,230	3,813	3,747	3,724	3,542	3,544	3,552	3,414
N & U	7,478	6,341	5,398	4,594	3,809	3,737	3,422	3,221	3,204	1,764	1,687
Total	37,941	35,881	34,593	33,033	33,243	33,769	33,548	31,794	30,802	30,768	29,730

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished. Note: 2003 figures are final.

Table 2.11: GCE A-levels achieved in Chemistry (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	6,884	7,463	8,205	8,124	9,044	10,092	10,353	10,552	10,504	10,511	10,539
B	7,498	7,628	7,486	8,488	9,086	8,952	8,920	8,937	8,457	8,251	8,298
C	6,556	6,762	7,105	7,437	7,734	7,705	7,611	7,406	7,115	6,693	6,443
D	6,392	6,102	6,598	6,022	6,297	6,004	5,974	5,840	5,469	5,084	4,799
E	5,409	5,442	5,498	4,812	5,029	4,564	4,256	4,048	3,982	3,411	3,274
N & U	8,236	7,834	7,401	5,538	5,071	4,576	3,806	3,478	3,175	1,601	1,534
Total	40,975	41,231	42,293	40,418	42,262	41,893	40,920	40,261	38,702	35,551	34,887

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished. Note: 2003 figures are final.

Table 2.12: GCE A-levels achieved in Design and Technology Subjects (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	1,126	1,138	1,291	1,392	1,507	1,629	1,892	2,059	2,347	2,124	2,542
B	1,465	1,624	1,463	1,615	1,752	1,860	2,050	2,353	2,337	3,399	3,774
C	2,252	2,298	2,453	2,639	2,850	3,128	3,421	3,794	3,766	3,915	4,339
D	2,340	2,463	2,335	2,550	2,651	3,008	3,176	3,238	3,209	3,413	3,720
E	1,870	1,812	1,829	1,848	1,729	2,171	1,954	1,991	1,994	1,993	2,006
N & U	1,880	1,712	1,388	1,292	1,192	1,524	1,246	1,215	1,256	655	641
Total	10,934	11,046	10,760	11,336	11,680	13,320	13,739	14,650	14,909	15,499	17,022

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished. Note: 2003 figures are final.

Tables Section 2. continued
Secondary education

Table 2.13: GCE A-levels achieved in Computing (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	919	1.003	1,1,06	1,123	1,190	1,237	1,514	1,684	1,934	2,402	2,488
B	1,269	1,198	1,287	1,386	1,561	2,040	2,356	2,851	3,334	4,133	4,598
C	1,612	1,631	1,797	1.945	2,198	3087	3,508	4,190	5,016	5,859	6,466
D	1,930	1,883	1,965	2.078	2,404	2,990	3,761	4,550	5,229	6,500	6,696
E	1,797	1,687	1,817	1,807	2,088	2,533	3,003	3,369	3,866	5,270	5,045
N & U	2,176	2,184	2,224	2,371	2,545	2,770	2,980	3,002	3,283	2,599	2,220
Total	9.703	9,586	10,196	10,710	11,986	14,657	17,122	19,646	22,662	26,763	27,513

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
Note: 2003 figures are final.

Table 2.14: GCE A-levels achieved in Biology (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	6,213	7,026	7,473	7,295	8,466	9,484	9,966	9.940	10,122	11,461	11,272
B	7,353	7,854	8,227	9,762	11,108	11,218	10,727	10,818	10,393	9,920	10,347
C	7,527	8,593	8,884	9,900	10,885	10,944	10,796	10,687	10,254	9.825	9,896
D	8,213	8,714	8,864	9,309	10,029	9,905	9,694	9,387	8,666	8,870	8,409
E	7,667	8,097	7,952	7,705	8,308	7,977	7,572	7,346	6,922	6,702	6,545
N & U	10,775	10,567	10,855	8,082	7,910	7,908	7,055	6,472	6,025	3,538	3,360
Total	47,748	50,851	52,255	52,053	56,706	57,436	55,810	54,650	52,382	50,316	49,829

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
Note: 2003 figures are final.

Table 2.15: Numbers graduating in mathematical sciences in England and Wales (after full and part time study), compared with graduates in all subjects. And numbers proceeding to PGCE courses as compared with the DfEE Initial Teacher Training (ITT) target figures

Year	A. Number of Mathematics Graduates	B. Total Number of Graduates	C. Column A as a % of column B	D. Number of Maths Graduates proceeding to PGCE	E. Column D as a % of column A	DfEE/DfES target for initial teacher training (ITT) recruitment (in England)
1995	3,540	192,260	1.8	514	14.5	Unknown
1996	3,537	201,390	1.8	421	11.9	2,700
1997	3,297	203,226	1.6	398	12.1	2,370
1998	3,717	202,204	1.8	308	8.3	2,270
1999	3,839	206,763	1.9	366	9.5	2,110
2000	3,670	207,730	1.8	340	9.3	1,810
2001	3,640	213,190	1.6	329	8.8	1,940
2002	3,620	218,195	1.7	315	8.7	1,952

Source: Teacher Training Agency: Annual Reports; Higher Education Statistics Agency: First Destinations of Students, 1994/95, 1995/96, 1996/97, 1997/98 (and 1998/99, 1999/2000, 2000/01 and 2001/02).

Table 2.16: Percentage of all A level awards made to women (all boards, UK candidates)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Mathematics	34.2	34.9	35.1	34.8	35.3	36.2	36.2	37.4	37.0	36.9	37.3
Physics	21.9	21.8	21.7	21.4	21.9	22.9	23.1	22.9	22.1	23.2	22.9
Technology	17.4	17.7	17.3	19.5	24.9	23.6	25.1	27.5	27.9	35.9	37.4
Chemistry	41.5	43.1	43.8	44.1	44.6	45.8	47.6	48.6	49.8	51.0	51.7
Computing	19.2	18.0	17.2	16.6	16.7	19.1	20.4	22.3	23.0	26.4	26.5
Biology	60.9	60.7	60.4	59.7	59.2	59.5	61.0	61.6	62.0	62.0	61.6

Source: Joint Council for General Qualifications. 2003 figures are final.

Table 2.17: GCE A-levels achieved in Mathematics (all boards, UK women)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	4,964	5,238	5,951	6,283	6,552	7,123	7,360	7,566	7,482	8,314	8,759
B	4,016	4,298	4,333	5,859	5,205	5,188	5,199	5,054	5,005	4.045	4,438
C	3,775	3,983	3,978	4,055	4,402	4,276	4,242	4,265	4,187	3,034	3,112
D	3,300	3,274	3,185	3,286	3,442	3,339	3,395	3,369	3,332	2,095	2,146
E	2,550	2,393	2,298	2,407	2,372	2,363	2,429	2,364	2,425	1,274	1,246
N & U	3,583	3,010	2,509	2,171	2,079	2,115	2,151	1,997	1,957	665	643
Total	22,188	22,196	22,254	24,061	24,052	24,404	24,776	24,615	24,379	19,427	20,366

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
2003 figures are final.

Table 2.18: GCE A-levels achieved in Physics (all Boards, UK women)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	1,222	1,375	1,462	1,488	1,634	1,802	2,016	2,095	1,883	2,353	2,264
B	1,461	1,283	1,398	1,516	1,705	1,765	1,690	1,639	1,563	1,603	1,545
C	1,437	1,378	1,351	1,302	1,384	1,442	1,518	1,330	1,229	1,318	1,211
D	1,430	1,289	1,247	1,034	1,069	1,103	1,080	981	950	1,012	881
E	1,198	1,171	951	797	752	762	770	702	637	605	633
N & U	1,562	1,314	1,107	927	723	657	670	546	544	243	265
Total	8,310	7,810	7,516	7,064	7,267	7,531	7,744	7,293	6,806	7,134	6,799

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
2003 figures are final.

Table 2.19: GCE A-levels achieved in Chemistry (all Boards, UK women)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	2,569	2,970	3,371	3,640	4,055	4,686	5,018	5,420	5,458	5,608	5,758
B	3,215	3,379	3,353	3,836	4,187	4,314	4,397	4,558	4,416	4,408	4,445
C	2,756	2,970	3,186	3,355	3,564	3,535	3,722	3,638	3,569	3,468	3,329
D	2,790	2,721	2,982	2,694	2,791	2,764	2,805	2,744	2,599	2,456	2,356
E	2,331	2,419	2,482	2,052	2,207	1,977	1,911	1,796	1,825	1,553	1,504
N & U	3,351	3,326	3,149	2,266	2,056	1,918	1,606	1,423	1,425	654	650
Total	17,011	17,786	18,523	17,844	18,859	19,194	19,459	19,579	19,292	18,147	18,042

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
2003 figures are final.

Table 2.20: GCE A-levels achieved in Design and Technology Subjects (all Boards, UK women)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	215	225	255	327	407	448	521	628	746	921	1,178
B	268	313	297	376	486	519	599	731	758	1,434	1,637
C	438	431	452	562	803	798	943	1.099	1,134	1,481	1,672
D	394	440	389	482	605	699	747	867	806	1,070	1,189
E	312	296	277	294	372	407	414	470	470	534	537
N & U	276	253	189	170	236	267	218	236	239	123	145
Total	1,904	1,957	1,859	2,212	2,909	3,138	3,442	4,031	4,153	5,563	6,358

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
2003 figures are final.

Table 2.21: GCE A-levels achieved in Computing (all Boards, UK women)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	103	109	105	112	150	168	241	307	386	647	678
B	203	171	174	227	253	387	483	657	855	1,154	1,383
C	272	257	293	298	335	580	790	1,021	1,226	1,629	1,774
D	384	354	368	403	433	611	804	1,069	1,226	1,763	1,800
E	384	359	337	334	389	513	605	749	893	1,356	1,221
N & U	518	477	477	401	445	544	574	578	631	519	422
Total	1,865	1,727	1,753	1,776	2,006	2,802	3,497	4,381	5,217	7,068	7,278

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
2003 figures are final.

Table 2.22: GCE A-levels achieved in Biology (all Boards, UK women)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A	3,504	3,690	4,574	4,568	5,202	5,881	6,327	6,500	6,660	7,492	7,357
B	4,522	4,474	5,079	6,028	6,780	6,941	6,804	6,938	6,693	6,367	6,670
C	4,941	4,649	5,426	5,935	6,511	6,668	6,634	6,702	6,335	6,137	6,121
D	5,240	4,997	5,426	5,407	5,840	5,745	5,749	5,591	5,263	5,347	4,991
E	4,851	4,620	4,701	4,475	4,766	4,514	4,456	4,244	3,996	3,865	3,723
N & U	6,887	6,625	6,341	4,661	4,464	4,445	4,048	3,705	3,541	1,963	1,827
Total	29,945	29,055	31,548	31,073	33,564	34,194	34,018	33,679	32,488	31,171	30,689

Source: Joint Council for General Qualifications. Note: From 2002 onwards, following Curriculum 2000, grade N has been abolished.
2003 figures are final.

Tables Section 3.
Post-16 vocational education and training

Table 3.1: BTEC First and National Diploma Registrations for Engineering

BTEC First	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Employers	58	39	36	64	58	83	83	68	66
Further Education	5,803	3,533	2,889	2,555	2,450	2,307	2,064	2,092	3,148
Higher Education	10	0	14	4	8	0	6	10	20
Schools	315	154	75	42	24	16	21	27	23
Total	6,186	3,726	3,014	2,665	2,540	2,406	2,174	2,197	3,257

BTEC National	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Employers	1,565	1,570	1,728	1,809	2,001	2,799	2,691	2,680	1,692
Further Education	17,995	15,993	14,366	14,062	13,884	12,680	11,566	11,623	10,997
Higher Education	161	192	85	23	73	76	48	21	16
Schools	28	26	17	17	0	0	0	0	0
Total	19,749	17,781	16,196	15,911	15,958	15,555	14,305	14,324	12,705

Source: Edexcel Foundation - London - August 2003

Table 3.2: Engineering GVNQ Achievements - June 2001 (All UK Candidates)

	Active Engineering Candidates			Engineering Awards			All GVNQ Awards		
Level	1999	2000	2001	1999	2000	2001	1999	2000	2001
Foundation	952	797	348	398	371	167	8,940	9,671	5,105
Intermediate	3,968	3,582	837	2,171	1,859	506	46,435	42,690	10,862
Advanced	2,866	2,784	2,421	1,390	1,515	1,324	48,733	47,211	42,289

Source: Joint Council for Awarding Bodies, 2002, 2001. Note: In 2001 at Foundation and Intermediate Level the qualifications were developed and operated under new criteria and the data is not therefore comparable with earlier years.

Table 3.3: Engineering and Construction GNVQ and VCE Achievements, Full Awards – June 2003

	All Full Awards		Engineering Awards		Construction Awards	
Level	2002	2003	2002	2003	2002	2003
GNVQ Foundation	10,471	12,267	249	243	847	874
GNVQ Intermediate	47,354	69,385	1,069	978	106	93
Advanced VCE	25,378	34,081	312	408	134	121

Source: Joint Council, 2003. Note: In 2003 the advanced GNVQ was replaced by the advanced VCE

Table 3.4: Information Technology, Science and Manufacturing GNVQ and VCE Achievements, Full Awards – June 2003

	Information Technology Awards		Science Awards		Manufacturing Awards	
Level	2002	2003	2002	2003	2002	2003
GNVQ Foundation	2,940	3,616	186	450	69	88
GNVQ Intermediate	15,391	32,339	1,400	3,975	249	275
Advanced VCE	7,323	11,246	482	475	62	66

Source: Joint Council, 2003. Note: In 2003 the advanced GNVQ was replaced by the advanced VCE

Table 3.5: Number of NVQ/SVQ Awards in Engineering and Constructing (sic)

Engineering NVQ/SVQ

Year	Level 1	Level 2	Level 3	Level 4
1987/88	0	0	13	0
1988/89	0	0	121	0
1989/90	200	70	913	78
1990/91	629	379	1,893	256
1991/92	630	4,181	3,525	448
1992/93	990	11,138	5,033	438
1993/94	2,515	15,292	7,257	598
1994/95	3,919	20,466	13,101	835
1995/96	4,591	25,121	8,855	525
1996/97	4,861	31,029	14,099	190
1997/98	3,994	29,065	12,360	310
1998/99	2,221	29,144	14,406	372
1999/2000	1,593	26,812	17,814	338
2000/01	1,378	23,455	14,604	181
2001/02	2,700	15,800	14,100	-
TOTAL	30,201	231,952	127,625	4,569

Source: QCA, 2003, except 2001/02 which was National Statistics National Information System for Vocational Qualifications (NISVQ), and to the nearest 1,000; - = less than 1,000.

Table 3.6: Registrations for Engineering HND/HNC Courses:

HNC

Delivered by	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Employers	375	370	211	223	235	133	113	177	236
Further Education	6,244	5,601	5,474	5,755	6,116	5,765	5,224	4,499	3,436
Higher Education	2,128	1,664	1,508	2,164	1,901	1,948	1,720	1,708	1,602
Total HNC	8,747	7,635	7,193	8,142	8,252	7,846	7.057	6,384	5,274
Total, excluding employers	8,372	7,265	6,982	7,919	8,017	7,713	6,944	6,207	5,038

HND

Delivered by	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Employers	79	92	158	194	273	367	718	532	488
Further Education	2,394	2,430	2,790	2,690	2,151	2,508	2,214	2,249	2,053
Higher Education	4,717	4,783	4,114	3,623	3,356	2,869	2,539	1,981	1,633
Total HND	7,190	7,305	7,062	6,507	5,780	5,744	5,471	4,762	4,174
Total, excluding employers	7,111	7,213	6,904	6,313	5,507	5,377	4,753	4,230	3,686

Source: Edexcel Foundation - London - August 2003

Tables Section 4.
Higher education

Table 4.1: Home applicants accepted to engineering, technology and computing degree courses by discipline

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
General Engineering	1,294	1,516	2,206	2,998	3,371	3,462	2,810	2,425	2,228	2,278	2,023	1,928	1,930	1,955	1,996	2,056
Civil Engineering	1,713	2,244	2,594	3,052	3,265	3,157	2,752	2,438	2,166	1,925	1,820	1,682	1,614	1,625	1,690	1,871
Mechanical Engineering	2,419	2,591	2,702	2,937	3,493	3,829	3,631	3,350	3,298	3,298	3,430	3.297	3,163	2,985	3,028	3,157
Aerospace Engineering	600	769	785	787	887	896	902	885	914	986	1,058	1,140	1,255	1,327	1,326	1,397
Naval Architecture															92	83
Electronic & Electrical Engineering	2,676	3,538	3,529	3,922	4,663	4,507	4,191	3,870	3,737	3,893	3,618	3,572	3,739	3,951	5,110	4272
Production/Manufacturing	684	797	914	1,232	1,199	1,314	1,238	1,418	1,180	1,242	1,178	1,155	1,312	1,372	1,355	1,177
Chemical/Process/Energy Engineering	799	944	1,033	1,109	1,212	1,156	1,048	939	893	956	910	843	718	660	681	676
Technology subjects	309	299	343	538	510	586	1,242	1,075	1,100	1,309	1,232	1,191	1,116	1,067	946	816
Other engineering & technologies	213	225	257	261	324	244	313	276	289	303	323	319	255	298	908	1016
Combinations	2,934	2,085	2,172	2,317	2,391	2,384	1,499	2,233	2,127	1,934	1,787	1,859	1,656	1,493	434	474
Total Engineering & Technology	**13,641**	**15,008**	**16,535**	**19,153**	**21,315**	**21,535**	**19,156**	**17,645**	**16,932**	**17,001**	**16,298**	**15,931**	**15,548**	**15,452**	**17,566**	**16,995**
Computer Science & related subjects	**4,174**	**4,950**	**5,688**	**6,623**	**7,873**	**8,842**	**8,401**	**9,751**	**10,820**	**12,383**	**14,018**	**16,227**	**17,880**	**20,335**	**18,719**	**16,998**

Source: UCAS/UCCA/PCAS Annual Reports/UCAS Datasets

Note: In 1994, Electrical & Electronic Engineering degree courses were reclassified from 'Electrical Engineering' to 'Combinations.' In 2002 "Aeronautical Engineering" was reclassified as Aerospace Engineering and "Naval Architecture".

Table 4.2: Home acceptances to engineering & computing degree courses 2003 by gender

	Women	Men	Total
Aerospace	112	1,285	1,397
Production/ Manufacturing	216	961	1,177
Chemical/Process/Energy	157	519	676
Electrical/ Electronic	419	3,853	4,272
Mechanical	226	2,931	3,157
Civil	241	1,630	1,871
General	268	1,788	2,056
Computing	2,814	14,181	16,998

Source: UCAS *Datasets 2003*

Table 4.3: Percentage of each gender by discipline 2003

	% Women	% Men
Aerospace	8.0	92.0
Production/Manufacturing	18.4	81.6
Chemical/Process/Energy	23.2	76.8
Electrical/Electronic	9.8	90.2
Mechanical	7.2	92.8
Civil	12.9	87.1
General	13.0	87.0
Computing	16.6	83.4

Source: UCAS *Datasets 2003*

Table 4.4: Enrolment of Foreign Students in UK Universities, by level, field, and 10 top countries of origin: 1995 and 1999

1995	Undergraduate		Graduate*	
	Natural Sciences	Engineering	Natural Sciences	Engineering
Country of origin				
Total S & E students	131,367	112,686	35,270	26,648
Total foreign S & E students	7,774	15,937	8,096	9,256
Greece	723	1,924	577	871
Malaysia	174	2,696	324	824
Ireland	1,297	1,260	486	281
West Germany	1,006	804	389	359
France	883	1,011	291	397
Hong Kong	216	1,108	91	355
Singapore	138	1,387	79	254
United States	519	91	243	107
Canada	88	20	141	107
China	5	110	406	659
Other	2,725	5,526	5,069	5,042
Percent foreign	5.9%	14.1%	23.0%	34.7%

Table 5.5: Destination and employment (%)

2001	Whole sample	Engineering	Computer Science
Permanent Employment	65	75	62
Short Term Employment	26	14	21
Unemployed	10	11	17
2002	**Whole sample**	**Engineering**	**Computer Science**
Permanent Employment	60	59	63
Short Term Employment	28	24	21
Unemployed	13	17	16

Source: CEL Ltd, *First Destination of 2001 Graduates, 2002 and The Graduate Experience 2002 Report, 2003*

Tables Section 5.
Graduate Employment

Table 5.1: Recent graduate starting (median) salaries by type of organisation* (£), 2001, 2002 & 2003

	2000/2001	2001/2002	June 2003
Energy, Water or Utility Company	19,000	19,500	20,000
Engineering or Industrial Company	18,000	19,000	19,400
IT or Software Company	19,450	21,000	20,000
Insurance Company	17,375	18,625	20,000
Accountancy or Professional Services Firm	17,000	17,500	19,800
Investment Bank or Fund Manager	23,125	23,500	35,000
Transport or Logistics Company	18,500	19,000	17,000
Public Sector	17,677	18,500	19,900
Law Firm	24,000	28,000	28,500
Manufacturing	20,500	22,250	22,400
Consulting or Business Services Firm			28,500
All graduates	19,000	19,600	20,300

- Salaries exclude London Weighting Allowance.

Source: IES/AGR Half-Yearly Review, July 2002 and AGR Graduate Recruitment Survey 2003, Winter and Summer Review by High Fliers Research Limited

Table 5.2: Median graduate starting salaries by function, 1995-1999 (£)

	1995	1996	1997	1998	1999
Buying, Sales, Marketing	14,000	15,250	16,250	16,875	17,375
Science, Engineering, R&D	14,624	15,300	16,000	17,250	19,000
IT/Computing	14,625	15,250	16,000	17,500	18,000
All functions	14,240	14,774	15,500	16,610	17,500
Accounting	13,500	14,550	15,500	16,750	17,000
Management	14,000	14,930	15,190	16,000	17,190

Source: AGR/IES 2000

Table 5.3: Median starting salaries (median) by business function or career area, in 2003

	June 2003
Marketing	21,500
Civil Engineering	19,500
Mechanical and Electrical/Electronic Engineering	18,900
IT	20,000
Financial Management	21,500
Accountancy	24,000
Investment Banking	35,000
Logistics	20,000
Actuarial Work	24,000
Solicitor or Barrister	28,000
Manufacturing Engineering	18,900
Science, Research and Development	18,500
Consulting	28,500
All graduates	20,300

- Salaries exclude London Weighting Allowance.

Source: AGR Graduate Recruitment Survey 2003, Summer Review by High Fliers Research Limited

Table 5.4: Year on year changes in vacancies, by type of organisation

INDUSTRY	Number of vacancies 2002	Number of vacancies 2003	% change
Energy, Water or Utility Company	248	264	+6.5
Engineering or Industrial Company	1,707	1,596	-6.5
IT or Software Company	98	88	-9.8
Insurance Company	176	165	-6.3
Accountancy or Professional Services Firm	2,728	2,555	-6.3
Investment Bank or Fund Manager	658	429	-34.8
Transport or Logistics Company	563	661	+17.5
Public Sector	651	661	+1.5
Law Firm	1,104	1,079	-2.3
Manufacturing	375	374	-0.3
Commercial or Retail Bank	598	584	-2.3
All Graduates	11,402	11,012	-3.4

Source: AGR Graduate Recruitment Survey 2003, Summer Review by High Fliers Research Limited

Table 5.6: Sector of employment (%), 2002

	Whole sample	Engineering	Computer science	In an ITEC role
Public sector	38	7	19	18
Private sector:				
Manufacturing industries	13	45	20	14
Professional/consultancy	20	22	37	40
Service industries	29	26	25	28

Source: CEL Ltd, *The Graduate Experience 2002 Report, 2003*

Table 5.7: Salary (£)

2002 graduates	Whole sample	Engineering	Engineering with accredited degree	Engineering without accredited degree	Computer Science
Median	14,000	18,000	17,735	18,000	16,000
2001 graduates	**Whole sample**	**Engineering**	**Engineering-with accredited degree**	**Engineering-without accredited degree**	**Computer science**
Median	15,000	18,000	18,000	16,776	17,000

Source: CEL Ltd, *First Destination of 2001 Graduates, 2002*

Table 5.8: Salary in deciles (£), 2002

Decile	Whole sample	Engineering	Computer science
1st	6,000	8,386	6,227
2nd	9,500	11,856	10,071
3rd	11,000	15,000	12,500
4th	12,244	16,726	14,902
5th	14,000	17,500	16,459
6th	15,600	18,110	18,000
7th	17,000	19,000	20,000
8th	18,000	19,965	21,000
9th	20,000	21,000	22,773
10th	24,000	24,493	29,743

Source: CEL Ltd, *The Graduate Experience 2002 Report, 2003*

Table 5.9 Median Salary and Class of Degree (£),2002

Base: employed graduates

	Whole sample	Engineering	Computer science
First Class Degrees	17,000	19,093	20,000
Upper Second Class Degrees	15,000	18,000	18,000
Lower Second Class Degrees	13,448	16,558	15,336
Third Class Degrees	13,407	15,918	12,502

Source: CEL Ltd, *The Graduate Experience 2002 Report, 2003*

Table 5.8: Salary in deciles (£), 2002

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1st	6,000	8,386	6,227
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7th	17,000	19,000	20,000
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9th	20,000	21,000	22,773
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Source: CEL Ltd, *The Graduate Experience 2002 Report, 2003*

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Lower Second Class Degrees	13,448	16,558	15,336
Third Class Degrees	13,407	15,918	12,502

Source: CEL Ltd, *The Graduate Experience 2002 Report, 2003*

Table 5.10: Employment status six months and 18 months after graduating (%)

	After six months				After 18 months			
	PS	AS	SS	A	PS	AS	SS	A
Permanent employment	35	42	37	41	48	64	59	53
Short term employment	16	19	21	18	6	8	7	9
Further study	32	20	24	20	34	14	20	23
Not available	4	4	5	5	3	4	4	4
Unemployed	13	15	14	16	9	10	10	11
N	*238*	*216*	*301*	*264*	*238*	*215*	*300*	*261*

PS = Pure science (biological and physical sciences)
AS = Applied science (maths, engineering/technology)
SS = Social science
A = Arts (humanities, languages, creative arts)

Source: IES, *What do Graduates Really do?*

Table 5.11: Main activity in 1997 by discipline of first degree (%)

	Biol sci	Phys sci	Math sci	Eng/Tech	Soc sci	Arts/Hum
In work	77	81	86	97	89	84
Further study	29	16	10	-	9	10
Unemployed	3	6	4	3	3	4
Other	1	-	1	3	3	6
N	*69*	*73*	*92*	*31*	*183*	*137*

Source: IES, *What do Graduates do Next?*

Table 5.12: Occupation of graduates in 1994 by subject of first degree (%)

	Biol sci	Phys sci	Math sci	Eng/ tech	Soc sci	Lang	Hum
Managers/administrators	7	8	11	4	18	14	12
Professionals	44	49	47	75	75	31	28
Associate professionals/technical	23	18	30	11	28	36	30
Clerical/secretarial	10	9	5	4	11	17	23
Sales	8	9	3	6	4	2	1
Personal & protective	6	4	2	-	7	3	4
Other	1	1	1	-	2	-	3
N	*84*	*97*	*133*	*47*	*260*	*126*	*78*

Source: IES, *What do Graduates Really do?*

Table 5.13: Occupation of graduates in 1997 by subject of first degree (%)

	Biol sci	Phys sci	Math sci	Eng/ Tech	Soc sci	Hum/ Arts
Manager/administrator	14	18	12	27	24	30
Professional	43	39	47	53	41	36
Associate professional/technical	33	20	24	13	27	31
Clerical/secretarial	-	13	4	-	5	7
Sales	8	5	8	7	2	4
Other	2	5	4	-	1	1
N	*51*	*56*	*74*	*30*	*154*	*96*

Source: IES, *What do Graduates do Next?*

Table 5.14: Mean salaries of 1985 graduates by selected subject (in 1996 prices) (£)

Subject	£	Subject	£
Clinical Dentistry	38,525	French	23,638
Law	32,812	Psychology	23,615
Economics	32,529	Management	23,422
Chartered Engineer	**29,481**	Arc. Sci.	23,322
Math. Sci.	**29,184**	English	22,948
Physics	29,105	Geography	22,589
Accountancy	28,997	Biology	22,314
Engineering	**28,797**	Vet. Science	22,279
Geology	28,792	Bio. Other	22,159
Clinical Medicine	28,106	Physical Sci: Other	22,004
Medical Sciences	26,445	Education: other	21,838
European. Languages	25,790	Language Studies	21,768
Business & Man.	25,687	Sociological Sci	21,568
Genetic Science	25,281	Soc.Sci: Other	21,494
Pharmacy	24,703	Humanities: other	21,474
Creative Arts	24,694	Teacher Training	21,303
History	24,305	Agr. Sci.	20,974
Chemistry	24,213	Philosophy	17,182
Politics	23,870	Theology	15,017
Biochemistry	23,853		

Source: HEFCE: Mapping the Careers of Highly Qualified Workers,. Dearing 1997

Tables Section 6.
Professional registration

Table 6.1: Proportions of registered engineers in the UK and some other developed countries

Country	Population	Graduate Engineers in work	Graduate Engineers as a % of the population	Registered Engineers	Registered Engineers as a % of the population	Registered Engineers as a % of engineering graduates
USA	278,060,000	1,568,000	0.56	400,000	0.14	25.5
UK	59,620,000	493,900*	0.83	190,400	0.32	38.6
Ireland	3,810,000			14,000	0.37	
Canada	31,160,000			152,000	0.49	
Australia	19,390,000			65,000	0.34	

Source: The Engineering Council, ONS Labour Force Survey

Note: These figures are drawn up for Chartered Engineers and their equivalent overseas * ONS Labour Force Survey figure for 2000. This figure, 493,900, is found in Appendix One in the report "Early Career Experiences of Engineering and Technology Graduates", Canny A, Davis D, Elias P, Hogarth T, February 2002, a report prepared for the Engineering and Technology Board by the Warwick Institute for Employment Research (IER). This report was subsequently up-dated. It was published in June 2003 and can be found at http://www.etechb.co.uk/archive/EarlyCareerExperiencesfinalreport.pdf. However, some changes were made in the both the classifications of the occupations considered and the definitions of the degrees of employees. As regards the later report science degree holders were included in the up-date but not in the first report, so the figures in the two reports cannot be directly compared.

Table 6.2: How important do you believe it is to become a European Engineer (Eur Ing)?

	Chartered Engineer	Incorporated Engineer	Engineering Technician
Essential	4.9%	12.0%	11.3%
Useful	44.8%	59.6%	59.7%
Unnecessary	50.3%	28.4%	29.0%

Source: The Engineering Council's *1999 Survey of Professional Engineers and Technicians*

Tables Section 7.
Employment conditions

Table 7.1: Average gross annual earnings including overtime of professional engineers, 2002, UK

Occupation	SOC (1990)	Annual earnings
All engineers and technologists	21	£33,324
Civil, structural, municipal, mining & quarrying engineers	210	£31,527
Mechanical engineers	211	£32,974
Electrical engineers	212	£34,573
Electronic engineers	213	£35,133
Software engineers	214	£37,060
Design & development engineers	216	£31,603
Process & production engineers	217	£32,391
Planning & quality control engineers	218	£29,132
Other engineers & technologists	219	£31,265

Source: Office for National Statistics: *New Earnings Survey 20012* © Crown Copyright 2003. Reproduced by permission of the Office for National Statistics.

Tables Section 7. continued
Employment conditions

Table 7.2: Average annual earnings of registered engineers and technicians

	1995	1997	1998	1999	2000	2001	2002	2003
Chartered Engineer	£35,654	£40,131	£42,159	£44,450	£44,803	49,997	51,960	49,088
Incorporated Engineer	£26,787	£29,918	£31,152	£32,842	£36,400	35,828	35,922	37,845
Engineering Technician	£22,215	£26,311	£26,453	£29,942	£28,639	30,273	34,014	32,993

Source: The Engineering Council (UK) 2002, The Engineering and Technology Board 2003.

Table 7.3: Median annual earnings of registered engineers and technicians

	1995	1997	1998	1999	2000	2001	2002	2003
Chartered Engineer	£31,000	£34,000	£35,800	£37,994	£38,000	41,000	42,500	43,477
Incorporated Engineer	£25,980	£26,850	£28,000	£28,980	£29,000	31,500	34,000	34,000
Engineering Technician	£21,000	£23,500	£24,101	£25,000	£25,400	26,643	28,500	29,000

Source: The Engineering Council (UK) 2002

Table 7.4: Average and median annual earnings of Chartered Engineers who are members of the following Institutions, Institutes or Societies, 2001 (1999 in brackets)

	Average per annum	Median per annum
Institution of Civil Engineers	£42,660 (£39,925)	£36,000 (£35,000)
Institution of Chemical Engineers	£59,479 (£52,024)	£46,037 (£45,000)
Institution of Electrical Engineers	£52,426 (£46,702)	£43,000 (£39,664)
Institution of Mechanical Engineers	£48,229 (£43,260)	£40,525 (£36,975)
Institute of Materials	£46,098 (£44,686)	£37,377 (£36,659)
British Computer Society	£57,105 (£49,489)	£48,000 (£40,000)

Source: The Engineering Council 1999, 2001

Table 7.5: Percentage of registrants saying they had been unemployed and seeking re-employment during the previous tax year

	1995	1997	1998	1999	2000	2001	2002	2003
Chartered Engineer	7.1%	6.6%	6.3%	5.4%	4.9%	5.5%	7.6%	9.2%
Incorporated Engineer	8.3%	7.0%	8.1%	6.4%	8.5%	5.4%	8.5%	7.3%
Engineering Technician	9.5%	8.6%	8.7%	5.6%	8.6%	6.3%	6.8%	7.9%
All respondents	7.6%	6.8%	6.9%	5.7%	5.9%	5.5%	7.8%	8.8%

Source: The Engineering Council (UK) 2002, Engineering and Technology Board 2003

Table 7.6: Please tick the one box which best describes the extent of your responsibility for technical matters:

	Chartered Engineer	Incorporated Engineer	Engineering Technician
All technical aspects of major engineering operation, project or plant	23.9%	18.9%	12.1%
All technical aspects of a complete engineering operation, project or plant	24.4%	24.5%	22.7%
One or more complete items in an operation, project or plant	15.8%	17.4%	15.8%
Substantial technical details, normally part of items in an operation, project or plant	15.3%	21.6%	28.5%
Minor technical details only	4.5%	6.2%	9.0%
No such technical responsibility (e.g. administration, commercial, teaching etc.)	16.2%	11.5%	11.9%

Source: The Engineering Council 2001

Table 7.7: Which of the following best describes the extent to which your work is supervised?

	Chartered Engineer	Incorporated Engineer	Engineering Technician
My work is unsupervised other than complying with a policy	48.8%	47.9%	54.2%
My work is occasionally reviewed in outline	40.6%	39.0%	29.0%
My work is regularly reviewed	8.8%	11.0%	13.1%
My work is frequently reviewed in detail	1.2%	1.4%	1.4%
All my work is checked in detail	0.6%	0.6%	2.2%

Source: The Engineering Council 2001

Table 7.8: Which of the following best describes the extent of your present authority?

	Chartered Engineer	Incorporated Engineer	Engineering Technician
I have overall responsibility for a substantial organisation including policy making	14.6%	10.5%	11.1%
I have full control over senior staff	8.5%	5.8%	3.5%
I supervise leaders of more than one group of qualified staff and others	19.5%	16.9%	12.9%
I supervise a group of qualified staff	27.4%	28.1%	27.0%
I have no managerial responsibilities, but may be assigned one or more assistants	19.3%	24.3%	24.2%
I have no authority, but may give guidance to others	10.5%	14.2%	20.9%
I am under full-time training	0.2%	0.2%	0.4%

Source: The Engineering Council 2001

Table 7.9: Proportion of employees who received on-the-job training in the last 12 months in establishments where such training was offered, analysed by size of establishment

Establishments with	Proportion of employees receiving on-the job training				% offering any such training
	1-24%	25-49%	50-74%	75%	
5-49 employees	45	17	10	27	55
50-249 employees	45	13	15	26	85
250+ employees	28	18	18	35	95
Total	45	17	11	28	61

Source: EMTA *1998 :Labour Market Survey of the Engineering Industry in Britain, Full Report*

Table 7.10: Proportion of adult employees aged 25 or more who received off-the-job training in the past 12 months from employers who offered such training, analysed by size of establishment

	Establishments with			Total
	5 - 49 employees	50-249 employees	250 + employees	
None	25	12	2	21
1-10%	31	49	34	35
11-24%	18	12	14	16
25-29%	14	14	22	14
50-74%	5	7	16	6
75% +	8	6	11	7
% offering off-the-job training	43	81	93	50

Source: EMTA *1998 :Labour Market Survey of the Engineering Industry in Britain, Full Report*

Table 7.11: Percentage of employers offering different types of training to adult employees aged 25 or more analysed by size of establishment

	Establishments with			Total
	5 - 49 employees	50-249 employees	250 + employees	
Short courses	70	78	88	73
Full-time courses	3	7	17	5
Part-time courses	9	18	83	12
Evening courses	13	23	39	16
Block/sandwich courses	2	11	21	5
Day release	19	29	52	23
Correspondence/distance learning	1	7	20	3
% offering any off-the-job training	43	81	93	50

Source: EMTA *1998 :Labour Market Survey of the Engineering Industry in Britain, Full Report*

Table 7.12: Percentage of establishments providing off-the-job training analysed by occupation and size of firm

	Establishments with			Total
	5 - 49 employees	50-249 employees	250 + employees	
Engineering manager	21	41	72	28
Other managers	20	44	74	29
Professional engineers, scientists, technologists	10	25	60	16
Other professionals	6	24	61	13
Engineering supervisors	12	33	63	20
Other supervisors	9	30	64	17
Technical engineers and engineering technicians	27	40	68	32
Craftsmen/women	29	36	61	33
Operators and assemblers	23	39	54	28
Administrative and clerical	24	47	74	32
Other employees	16	17	28	17
% offering any such training	**43**	**81**	**93**	**50**

Source: EMTA *1998 :Labour Market Survey of the Engineering Industry in Britain, Full Report*

Table 7.13: Please indicate whether you have undertaken any of the following in the past 12 months...

	Chartered Engineer	Incorporated Engineer	Engineering Technician
Employment sponsored training (5 or more days per year)	52.7% (48.6%)	55.4% (52.1%)	59.0% (56.4%)
Employment sponsored training (less than 5 days per year)	64.1% (66.3%)	66.3% (68.8%)	63.9% (64.1%)
Privately funded training for current work	15.5% (17.7%)	17.2% (11.7%)	21.7% (24.9%)
Privately funded training to change career	5.8% (5.4%)	8.3% (8.9%)	22.6% (14.5%)

Source: The Engineering Council 2001, and 1999 figures are given in barckets

Table 7.14: ...and if so, by what method?

	Employment -sponsored (5 days +)	Employment -sponsored (under 5 days)	Privately funded for current work	Privately Funded to Change career
Course	39.2% (36.3%)	47.7% (49.3%)	6.4% (7.1%)	2.7% (3.3%)
Distance learning	5.0% (4.5%)	2.1% (2.0%)	3.3% (4.0%)	2.2% (1.7%)
On-the-job training	16.3% (15.2%)	19.6% (19.4%)	3.1% (4.1%)	0.7% (0.8%)
Other	4.8% (4.0%)	6.6% (7.0%)	4.7% (5.4%)	1.5% (1.3%)
None in last 12 months	46.2% (50.1%)	35.4% (33.3%)	83.7% (81.0%)	93.2% (93.2%)

Source: The Engineering Council 2001, 1999 figures in brackets

Tables Section 8.
Engineers in the economy

Table 8.1: Qualifications of top executives of manufacturing companies in Britain:

Category	Number	%
Unqualified	27,000	62
Qualified in Science/Engineering/Technology	10,000	24
Qualified in Accountancy	2,700	6
Other graduates	3,000	7
Total	43,000	100

Source: IER: Engineers in Top Management

Table 8.2: Top executives of FTSE 100 companies by subject of qualification, engineers

	Engineers	Accountants	Other Disciplines/ No such qualification	Total Top Executives
Industry	13	3	16	32
Commerce	3	10	32	45
Finance	1	2	20	23
All sectors	17 (16)	15 (17)	68 (67)	100

Source: Engineering Council/Royal Academy of Engineers/IER
Note: These are 1997 figures with some December 2000 figures in brackets

Table 8.3: Top executives of FTSE 100 companies by subject of qualification, engineers and scientists, all sectors

	Engineers	Scientists	Accountants	Others	Total Top Executives
2001	15	10	20	65	100
2004	12	12	20	66	100

Source: Engineering Council 2001 and Engineering and Technology Board 2004

Table 8.4: Distribution of registered engineers by main eleven industry level Standard Industrial Classification (SIC) 1992

Percentage Distribution

SIC (1992)	1995	1997	1999	2000	2001	2002	2003
1. Agriculture	0.3	0.3	0.4	0.2	0.2	0.2	0.3
2. Mining and Quarrying	1.1	1.0	0.9	1.3	0.5	0.8	0.7
3. Manufacturing	31.7	33.3	34.1	37.8	38.1	39.4	40.0
4. Electricity, Gas and Water Supply	9.5	9.0	9.2	11.1	8.7	8.9	8..8
5. Construction	8.9	9.3	12.9	7.6	8.5	7.8	7.2
6. Wholesale and Retail Trade	0.4	0.5	0.6	0.5	0.5	0.4	0.4
7. Transport & Communication	5.1	5.1	5.2	5.2	6.3	6.4	5.9
8. Finance and Business	23.8	24.9	19.1	18.1	20.7	19.5	19.9
9. Public Administration	10.6	10.7	10.8	10.1	10.2	9.7	9.5
10. Education and Health	7.7	6.5	6.0	7.3	5.7	6.2	6.7
11. Other Services	0.7	0.6	0.8	0.8	0.8	0.7	0.5

Source: Engineering Council Survey of Professional Engineers and Technicians and Survey of Registered Engineers 1995,1997, 1999, 2000, 2001 & 2002 and Engineering and Technology Board Survey of Registered Engineers, October 2003, http://www.engc.org.uk/who_we_are/Survey_reg_eng_2003.pdf and http://www.etechb.co.uk/archive/2003_Survey.pdf.

Table 8.5: Distribution of engineering graduates by main eleven industry level Standard Industrial Classification (SIC) 1992

Percentage Distribution

SIC (1992)	2000
1. Agriculture	0.2
2. Mining and Quarrying	1.7
3. Manufacturing	33.0
4. Electricity, Gas and Water Supply	3.4
5. Construction	12.0
6. Wholesale and Retail Trade	3.6
7. Transport & Communication	6.2
8. Finance and Business	28.6
9. Public Administration	6.8
10. Education and Health	5.0
11. Other Services	1.1

Source: DTI, Labour Force Survey, as at summer June to August 2000

Table 8.6: Distribution of professional engineers and technologists by Standard Occupational Classification (SOC 2000) and by main eleven industry level Standard Industrial Classification (SiC) 1992

Percentage Distribution

SIC (1992)	2001
1. Agriculture	0.3
2. Mining and Quarrying	2.4
3. Manufacturing	47.5
4. Electricity, Gas and Water Supply	3.7
5. Construction	14.1
6. Wholesale and Retail Trade	1.7
7. Transport & Communication	6.5
8. Finance and Business	18.6
9. Public Administration	2.6
10. Education and Health	2.1
11. Other Services	0.5

Source: Office for National Statistics, Labour Force Survey, as at spring March to May 2001

Table 8.7: An analysis of the "Malpas Universe" using the Office for National Statistics' Standard Occupational Classification 2000

Standard Occupational Classification	All in employment
2121 Civil engineers	66,559
2122 Mechanical engineers	60,965
2123 Electrical engineers	42,378
2124 Electronics engineers	30,993
2125 Chemical engineers	6,040
2126 Design and development engineers	63,737
2127 Production and process engineers	42,437
2128 Planning and quality control engineers	36,018
2129 Engineering professionals n.e.s.	76,010
2131 IT strategy and planning professionals	135,512
2132 Software professionals	327,558
3111 Laboratory technicians	69,880
3112 Electrical/electronic technicians	32,520
3113 Engineering technicians	62,938
3114 Building and civil engineering technicians	29,414
3115 Quality assurance technicians	21,569
3119 Science and engineering technicians n.e.s.	56,240
312 Draughtpersons and Building inspectors	56,012
3131 IT operations technicians	119,267
3132 IT user support technicians	71,627
5215 Welding trades	98,884
5231 Motor mechanics, autoengineers	207,880
5233 Autoelectricians	9,489
5241 Electricians, electrical fitters	249,263
5242 Telecommunications engineers	58,843
5243 Line repairers and cable joiners	14,787
5244 TV, video and audiodesigners	22,355
5245 Computer engineers, installation and maintenance	46,215
5249 Electrical/electronics engineers n.e.s.	103,647
5314 Plumbers, heating and ventilation engineers	158,800
Total of the above	**2,377,837**

Note: Office for National Statistics (ONS) Labour Force Survey , spring quarter, March to May 2001; n.e.s. = not elsewhere specified. This Malpas Universe estimate did not include code 2111 Chemists, code 2112 Biologists, Scientists and Biochemists and code 2113 Physicists, Geologists and Meteorologists; these total 31, 378, and 69,076 and 18,446 respectively. Code 5232, for Vehicle body builders and repairers, was also not included and this occupational category was estimated to number 44,181. If all these are included in the Malpas Universe estimate then the total figure rises from 2,377,837 to 2,540,918

Tables Section 8. continued

Engineers in the economy

Table 8.8: Trends in the employment of graduate engineers and technologists, 1992 – 2000, Men
'000s of persons: analysis by two-digit Standard Occupational Classification (SOC 1990)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Men									
Aged 21-29									
21 - Engineers and Technologists	37.7	33.0	33.5	30.6	34.3	34.4	23.7	35.1	32.1
26 – Architects, Town Planners, and Surveyors	0.5	0.0	0.0	0.6	0.5	1.1	0.5	1.3	1.7
30 – Scientific Technicians, Architectural and Town Planner Technicians	1.3	3.0	3.0	2.9	0.9	3.5	4.4	2.4	3.1
31 – Draughtspersons, Quantity and other Surveyors	2.3	1.0	2.6	1.2	2.7	2.3	1.9	3.3	1.7
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	8.2	11.0	10.3	8.3	12.4	9.5	10.9	8.0	16.4
99 – Other Occupations	39.2	43.0	52.3	47.3	39.2	46.7	44.5	36.9	35.9
Total	**89.2**	**90.9**	**101.8**	**90.9**	**90.0**	**97.4**	**85.9**	**87.0**	**90.9**
Aged 30 – 44									
21 - Engineers and Technologists	56.2	57.2	58.1	54.9	52.0	57.5	60.2	57.4	58.3
26 – Architects, Town Planners, and Surveyors	0.0	1.4	2.4	1.4	3.1	0.6	1.8	1.7	3.5
30 – Scientific Technicians, Architectural and Town Planner Technicians	1.5	2.9	2.2	4.9	2.5	1.9	1.3	1.9	1.9
31 – Draughtspersons, Quantity and other Surveyors	0.0	4.0	2.3	2.5	4.2	4.9	3.3	3.9	2.8
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	8.6	10.2	14.1	12.3	13.8	16.2	17.0	21.8	19.6
99 – Other Occupations	94.7	96.7	104.0	107.1	95.4	104.1	102.4	102.9	114.4
Total	**161.0**	**172.4**	**183.2**	**183.1**	**171.0**	**185.2**	**186.0**	**189.6**	**200.6**
Aged 45 – 59									
21 - Engineers and Technologists	48.3	40.3	43.4	41.6	33.8	48.3	37.0	40.1	39.8
26 – Architects, Town Planners, and Surveyors	1.2	2.2	0.8	0.8	1.9	1.6	2.6	2.2	2.6
30 – Scientific Technicians, Architectural and Town Planner Technicians	1.2	0.6	1.1	1.5	2.4	2.3	0.7	1.2	3.0
31 – Draughtspersons, Quantity and other Surveyors	2.5	2.1	2.1	2.2	1.5	0.4	1.1	0.9	0.8
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	2.6	4.6	4.7	5.7	4.3	5.7	5.5	4.2	4.9
99 – Other Occupations	107.9	127.0	112.6	117.8	104.0	111.4	117.0	116.3	123.8
Total	**163.6**	**176.7**	**164.8**	**169.6**	**148.0**	**169.7**	**163.9**	**165.0**	**175.0**
TOTAL OF MEN (all ages)	**413.8**	**440.0**	**449.8**	**443.6**	**409.0**	**452.3**	**435.8**	**441.6**	**466.5**

Source: Labour Force Survey, Office for National Statistics. Note: The Labour Force Survey (LFS) data presented here is based on information from the spring quarter (March to May) from 1992 to 2000. The LFS is the largest representative sample of working age individuals in the UK and the spring quarter is the largest of the four quarterly surveys. However, despite the large sample size, of approximately 120,000 individuals aged over 16 or 60,000 households, it is important to remember that analyses of sub-groups are subject to sampling error. This can have the effect of producing fluctuations in the data due to sampling error. See Appendix One in the report "Early Career Experiences of Engineering and Technology Graduates", Canny A, Davis D, Elias P, Hogart T, February 2002, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment research (IER).

Table 8.10: Trends in the employment of graduate engineers and technologists, 1992 – 2000, Men and Women
'000s of persons: analysis by two-digit Standard Occupational Classification (SOC 1990)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Men and Women									
Aged 21-29									
21 - Engineers and Technologists	40.0	35.9	38.1	34.2	39.6	35.6	26.0	39.3	35.3
26 – Architects, Town Planners, and Surveyors	0.8	0.0	0.0	0.6	0.5	1.1	0.9	1.3	2.1
30 – Scientific Technicians, Architectural and Town Planner Technicians	1.8	3.7	3.8	4.8	2.5	4.6	4.4	2.4	3.1
31 – Draughtspersons, Quantity and other Surveyors	2.3	1.0	2.6	1.2	3.0	3.1	2.3	3.3	1.7
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	9.2	11.8	10.8	8.7	12.9	10.0	11.3	9.6	17.2
99 – Other Occupations	45.4	55.5	67.5	59.8	50.9	58.1	52.3	42.7	43.8
Total	**99.6**	**108.0**	**122.8**	**109.2**	**109.3**	**112.5**	**97.3**	**98.6**	**103.2**
Aged 30 – 44									
21 - Engineers and Technologists	58.0	57.8	59.3	55.6	53.9	60.1	62.1	59.2	61.3
26 – Architects, Town Planners, and Surveyors	0.0	1.8	2.8	1.4	3.5	0.6	2.2	2.1	4.0
30 – Scientific Technicians, Architectural and Town Planner Technicians	1.5	2.9	2.6	5.7	2.8	2.7	1.6	2.4	2.3
31 – Draughtspersons, Quantity and other Surveyors	0.4	4.0	2.3	2.5	4.5	4.9	3.3	3.9	2.8
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	9.0	10.5	14.5	12.7	14.1	16.8	17.3	22.2	20.1
99 – Other Occupations	102.5	109.7	118.3	121.1	112.3	118.3	112.2	114.3	123.8
Total	**171.2**	**186.8**	**199.7**	**199.0**	**191.2**	**203.3**	**198.7**	**204.0**	**214.3**
Aged 45 – 59									
21 - Engineers and Technologists	48.3	40.3	43.4	42.3	34.1	49.1	37.0	40.6	40.2
26 – Architects, Town Planners, and Surveyors	1.2	2.2	0.8	0.8	1.9	1.6	2.6	2.2	2.6
30 – Scientific Technicians, Architectural and Town Planner Technicians	1.2	0.9	1.1	1.5	2.4	2.3	0.7	1.2	3.0
31 – Draughtspersons, Quantity and other Surveyors	2.5	2.1	2.1	2.2	1.5	0.4	1.1	0.9	0.8
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	2.6	4.6	4.7	5.7	4.8	5.7	5.5	4.2	5.3
99 – Other Occupations	110.7	131.8	115.9	120.2	108.1	115.2	118.8	119.1	124.6
Total	**166.3**	**181.9**	**168.1**	**172.7**	**153.0**	**174.2**	**165.7**	**168.2**	**176.4**
Percentage of the total that are women	5.3%	7.7%	8.3%	7.8%	9.8%	7.7%	5.6%	6.2%	5.6%
TOTAL OF MEN AND WOMEN (all ages)	**437.1**	**476.7**	**490.6**	**480.9**	**453.5**	**490.0**	**461.7**	**470.8**	**493.9**

Source: Labour Force Survey, Office for National Statistics. Note: The Labour Force Survey (LFS) data presented here is based on information from the spring quarter (March to May) from 1992 to 2000. The LFS is the largest representative sample of working age individuals in the UK and the spring quarter is the largest of the four quarterly surveys. However, despite the large sample size, of approximately 120,000 individuals aged over 16 or 60,000 households, it is important to remember that analyses of sub-groups are subject to sampling error. This can have the effect of producing fluctuations in the data due to sampling error. See Appendix One in the report "Early Career Experiences of Engineering and Technology Graduates", Canny A, Davis D, Elias P, Hogart T, February 2002, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment research (IER).

Table 8.9: Trends in the employment of graduate engineers and technologists, 1992 – 2000, Women
'000s of persons: analysis by two-digit Standard Occupational Classification (SOC 1990)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Women									
Aged 21-29									
21 - Engineers and Technologists	2.3	3.0	4.6	3.5	5.2	1.2	2.3	4.3	3.2
26 – Architects, Town Planners, and Surveyors	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4
30 – Scientific Technicians, Architectural and Town Planner Technicians	0.5	0.8	0.7	1.9	1.6	1.2	0.0	0.0	0.0
31 – Draughtspersons, Quantity and other Surveyors	0.0	0.0	0.0	0.0	0.3	0.8	0.4	0.0	0.0
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	1.0	0.8	0.5	0.4	0.4	0.5	0.4	1.5	0.8
99 – Other Occupations	6.2	12.6	15.2	12.5	11.6	11.4	7.8	5.8	7.9
Total	**10.4**	**17.1**	**21.0**	**18.3**	**19.3**	**15.2**	**11.3**	**11.6**	**12.3**
Aged 30 - 44									
21 - Engineers and Technologists	1.8	0.7	1.1	0.7	1.9	2.6	1.8	1.7	3.0
26 – Architects, Town Planners, and Surveyors	0.0	0.4	0.4	0.0	0.3	0.0	0.5	0.4	0.4
30 – Scientific Technicians, Architectural and Town Planner Technicians	0.0	0.0	0.4	0.8	0.4	0.7	0.3	0.5	0.4
31 – Draughtspersons, Quantity and other Surveyors	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	0.3	0.3	0.4	0.4	0.3	0.6	0.4	0.4	0.4
99 – Other Occupations	7.7	13.0	14.3	14.0	16.9	14.2	9.8	11.4	9.4
Total	**10.2**	**14.4**	**16.6**	**15.9**	**20.2**	**18.1**	**12.8**	**14.5**	**13.7**
Aged 45 – 59									
21 - Engineers and Technologists	0.0	0.0	0.0	0.7	0.3	0.7	0.0	0.4	0.4
30 – Scientific Technicians, Architectural and Town Planner Technicians	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 – Computer Analysts and Programmers, Software Engineers and Computer Engineers	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.4
99 – Other Occupations	2.8	4.8	3.3	2.4	4.1	3.8	1.8	2.8	0.8
Total	**2.8**	**5.1**	**3.3**	**3.1**	**5.0**	**4.5**	**1.8**	**3.2**	**1.5**
TOTAL WOMEN (all ages)	**23.4**	**36.6**	**40.9**	**37.3**	**44.5**	**37.7**	**25.9**	**29,3**	**27.5**

Source: Labour Force Survey, Office for National Statistics. Note: The Labour Force Survey (LFS) data presented here is based on information from the spring quarter (March to May) from 1992 to 2000. The LFS is the largest representative sample of working age individuals in the UK and the spring quarter is the largest of the four quarterly surveys. However, despite the large sample size, of approximately 120,000 individuals aged over 16 or 60,000 households, it is important to remember that analyses of sub-groups are subject to sampling error. This can have the effect of producing fluctuations in the data due to sampling error. See Appendix One in the report "Early Career Experiences of Engineering and Technology Graduates", Canny A, Davis D, Elias P, Hogart T, February 2002, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment research (IER).

Table 8.11: The employment of technicians by main economic sector, 2002: distribution by percentage

	Science & engineering technicians	Draught-persons & building inspectors	IT service delivery occupations	Metal forming, welding & related	Metal machining fitting, instrument making	Vehicle trades	Electrical trades	All else	TOTAL
Agriculture	1	0	-	-	0	0	0	1	1
Utilities	7	3	2	1	3	0	5	1	1
Manufacturing	43	33	17	78	75	12	25	14	16
Construction	9	17	1	13	6	1	33	7	8
Distribution, hotels& catering	3	2	7	3	6	71	8	20	20
Transport & communications	3	0	7	1	4	10	13	7	7
Business services	10	39	39	2	3	2	9	16	16
Public sector	24	5	23	1	3	2	4	27	26
Other services	1	1	3	1	1	1	2	6	6
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Labour Force Survey, Office for National Statistics, averaged quarterly estimates, December 2001 to November 2002.

Table 8.12: Those with appropriate SET qualifications by Gender (000's) in 2002

	Male	Female	Total	% Female
Biological sciences	151	150	301	49.7
Physical Sciences	319	125	444	28.2
Mathematics	189	74	263	28.1
Computer Science	140	37	177	21.1
Engineering	453	25	478	5.3
Technology	49	21	71	30.1
SET Subjects	1,301	433	1,734	25.0
Other Subjects	2,064	2,796	4,860	57.5
All Subjects	33,65	3,229	6,594	49.0

Source: Labour Force Survey, Office for National Statistics, March to May 2002.

Tables Section 8. continued
Engineers in the economy

Table 8.13: Those in SET qualifications by Gender (000's) in 2002
analysis by Standard Occupational Classification 2000 (SOC 2000)

	Male	Female	Total	% Female
Science professionals	69	48	117	41.1
Engineering professionals	407	22	429	5.1
ICT professionals	349	67	416	16.0
Science Research professionals	11	-*	16	-*
SET professionals	836	142	978	14.5
Other professionals	1,110	1,200	2,310	51.9
Other occupations	13,828	11,459	25,082	45.7
All Occupations	15,574	12,796	28,730	45.1

Source: Labour Force Survey, Office for National Statistics, March to May 2002.
Note: * sample size too small

Table 8.14: Those in SET qualifications by Ethnicity (000's) in 2002
analysis by Standard Occupational Classification 2000 (SOC 2000)

	White	Minority Ethnic	% Minority Ethnic
Science professionals	107	10	8.5
Engineering professionals	416	13	3.0
ICT professionals	372	44	10.5
Science Research professionals	14	-*	-*
SET professionals	909	69	7.0
Other professionals	2,149	160	6.9
Other occupations	23.040	1,479	6.0
All Occupations	26,625	1,739	6.1

Source: Labour Force Survey, Office for National Statistics, March to May 2002.
Note: * sample size too small

Tables Section 9.
Technology, Education and Economic Growth

Table 9.1: Relative Labour Productivity Levels, 1999. Total Economy.

	Aggregate GDP (Market Prices)	Aggregate GDP (Market Prices)	Sector Base Estimates (Factor Cost)
	GDP per person employed	GDP per hour worked	GDP per hour worked
US	139	126	130
France	115	124	129
Germany	107	111	117
Japan	101	94	89

Source: O'Mahony and de Boer, National Institute of Economic and Social Research, 2002.

Table 9.2: Relative Output per Hour Worked by Sector, 1999 (UK = 100)

	US	France	Germany
Agriculture, Forestry and Fishing	189	104	51
Mining	78	43	20
Gas, Electricity and Water	157	114	65
Manufacturing	155	132	129
Construction	114	108	101
Transport and Communications	113	101	88
Distributive Trades	161	150	112
Financial and Business Services	153	126	161
Personal Services	97	93	147
Non-Market Services	84	107	87
Total Economy	130	129	117
Market Economy only	139	122	119

Source: O'Mahony and de Boer, National Institute of Economic and Social Research, 2002.

Footnotes

1 "Views of Engineering as a Career", EMTA, Summary Report, Conducted for EMTA by MORI, March 1998. The most recent report was undertaken in January - February 2001. This study found little change in young people's perceptions about engineering since 1998.

2 A male/female split was not published in 2001 for all the job categories.

3 "Gender Stereotyping in Career Choice", Employment Research Institute, Napier University, Edinburgh, January 2004. See http://www.napier.ac.uk/depts/eri/research/genderstereo.htm Stage One of the research consisted of a literature review, Stage Two was a self-completion survey and Stage Three consisted of in-depth interviews carried out by career advisers with 82 pupils during September 2003. Executive summary is found at http://www.napier.ac.uk/depts/eri/Downloads/GSES.pdf

4 "Tomorrow's World, Today's Reality. STM and teachers: perceptions, views and approaches", Department of Education, University of Bath, June 2003, a study commissioned by ETB, http://www.etechb.co.uk/archive/etbresearch.asp The methodology involved a series of focus groups with teachers held between October and November 2002. This was followed by a series of interviews and the interviewees included Government officers, SETNET co-ordinators, Higher Education Institutions, School-industrial link agencies and Tutors. Finally questionnaires were sent to schools and a total of 134 were returned and this added up 19% of all the teachers that were sent a questionnaire; this is a relatively high percentage response rate.

5 Among the main blockers were images associated with engineers and engineering, which were seen as unclear, inconsistent and broadly negative; links within schools, between schools and Higher Education Institutions and between schools and industry; curriculum pathways, which were sometimes seen as inappropriate to engineering; and general limitations of the curriculum, types of assessment and accountability.

6 "Ready SET Go: A review of SET study and careers choice", Institute for Employment Studies (IES), University of Warwick, June 2003, a study commissioned by the ETB, http://www.etechb.co.uk/archive/etbresearch.asp This review was a comprehensive search of academic literature and policy literature in the area of SET, with the final selection being based on how important the literature was and what impact it had achieved. There were two further criteria: literature which had often been quoted elsewhere and which had been used to form policy was given priority.

7 The Institute of Chemical Engineers (IChemE), taken from their website promoting chemical engineering as a career at http://www.whtnotchemeng.com.

8 "Young peoples attitudes to work, careers and learning", Roffey Park Management Institute, September 2000.

9 "Career Perceptions and Decision-Making", Foskett, Hemsley-Brown, Centre for Research in Education Marketing, University of Southampton, October 1997.

10 See Chapter 4, "Career Perceptions and Decision-Making", Foskett, Hemsley-Brown, Centre for Research in Education Marketing, University of Southampton, October 1997.

11 See Chapter 6, "Career Perceptions and Decision-Making", Foskett, Hemsley-Brown, Centre for Research in Education Marketing, University of Southampton, October 1997.

12 "The Dynamics of Decision-making in the Sphere of Skills' Formation", DfEE Skills Task Force Research Paper 2, Professor Roger Peen, September 1999.

13 "Connexions: the best start in life for every young person", DfEE, 2000.

14 "Work-Related Learning Activities in Primary Schools", DfEE, September 1999.

15 "Relations between parent attitudes, parent activities and children's self-perception of ability", Bleeker M, 2001.

16 "The Dynamics of Decision-making in the Sphere of Skills' Formation", DfEE Skill Task Force, Research Paper 2, Professor Roger Penn, September 1999; Russell and Woodman, 1998.

17 "Science and the Public: A Review of Science Communications and Public Attitudes to Science in Britain", Office for Science and Technology (OST) and the Wellcome Trust, October 2000. 1200 people were interviewed using a quota sample method with quotas set on age, sex and social grade. There was a booster sample of 200 members of minority ethnic groups and 400 in Scotland to allow more detailed analysis of these groups of special interest, http://www.wellcome.ac.uk/en/images/sciencepublic_3391.pdf

18 "Engineering Our Future", Report of the Committee of Inquiry into the Engineering Profession, Chairman Sir Montague Finniston, H.M.S.O., January 1980, Cmnd 7794, Appendix G, pages 242 - 246. 1,667 interviews took place 22 June - 5 July 1978 with identified adults aged 18 or over. An additional 406 respondents were also questioned, these having been identified as having one or more children aged 11 - 19.

19 "Europeans, science and technology", Eurobarometer 55.2, European Commission, Research Directorate-General, December 2001, http://europa.eu.int/comm/research/press/2001/pr0612en-report.pdf

20 The Engineering Council (UK) believes that Design and Technology is a valuable subject to combine with the study of science and mathematics at post-16 level, and from there to continue studying science and engineering at degree level. See "Design and Technology in a Knowledge Economy", Kimbell R, Perry D, February 2001, http://www.engc.org.uk/publications/pdf/D&T.pdf Also most teachers believe that Design and Technology play an important role in developing both specific and generic skills and for understanding technology and engineering. See "Tomorrow's World, Today's Reality. STM and teachers: perceptions, views and approaches", Department of Education, University of Bath, June 2003, a study commissioned by ETB, http://www.etechb.co.uk/archive/etbresearch.asp page 7.

21 At present, i.e. in 2003, these subjects are English, Mathematics, Science, Design and Technology, Information and Communication Technology, a Foreign Language, Physical Education and Citizenship. Also at present, pupils can be "disapplied" from certain subjects (i.e. excused from studying) such as D&T and science in order to spend time on other subjects. Under the Government's 14 – 19 proposals, pupils will no longer have to take Design and Technology or a foreign language past the age of 14.

22 "Secondary Schools Curriculum and Staffing Survey", November 2002 (provisional), SFR25/2003, DfES, September 2003, England, http://www.dfes.gov.uk/rsgateway/DB/SFR/s000413/sfr25-2003.pdf See Table 2, Percentage of schools offering named subjects to pupils in year groups 7 to 11 (revised). Changed since 1996 were calculated taking the 95% confidence intervals into consideration and rounded. A subject is said to be 'offered' by a school for a particular subject group if it is being studied by at least one pupil in that age group.

23 In order to compare like with like, both these years figures are on a provisional basis. However the final figure for 2001 fell from 57,677 to 51,940, suggesting that quite a few people took AS level in Mathematics again in 2002 after deciding not to accept the offer of a grade in 2001. This will artificially raise the 2002 figure thereby possibly overestimating the "bounce back" observed in 2002. Also in 2001 the final figure for the proportion achieving a grade A-E in AS level fell from a provisional 71.4% to 66.6%.

24 It should, of course, be borne in mind that this is an imprecise indicator, since these data represent awards made (not candidates), and not all candidates for A-level are 18-years old.

25 An informal survey of the members of the Mathematical Association has apparently found that the number of students signed up to take Further Mathematics A-level reached a record low in September 2000. The Association alleges that the new-style modular A-level, introduced in 2000 as part of the Government's reform of A-levels, makes it harder for mathematically talented students to study Further Mathematics. The Association wrote in 2000 to the then Secretary of State for Education and Employment, Mr. David Blunkett, urging him to promote Further Mathematics A-level. See the "Times Educational Supplement", 12 May 2000.

26 "Annual Statistical Report 2002", Scottish Qualifications Authority, June 2003, see http://www.sqa.org.uk/files_ccc/SQA_Stats_02.pdf 2001 saw the continuation of changes in the examination system. For example the New Higher replaced SCE Higher Grade and Advanced Higher replaced Certificate of Sixth Year Studies (CSYS).

27 "Engineering Skills Formation in Britain: Cyclical and Structural Issues", Skills Task Force Research Paper 7, Mason G, National Institute of Economic and Social Research, September 1999. See also "An Assessment of Skill Needs in Engineering", one of a series of Skills Dialogues ", DfEE, 2001. And "2002 Labour Market Survey", EMTA, July 2002.

28 The Institute of Directors issued a press release and statement on the 16 August 2000, when Ruth Lea, Head of Policy Unit, stated concerns that standards were slipping. Also Chris Woodhead, the head of the schools' inspectorate Ofsted, stated in September 2000 that A-levels should be made more difficult and he called for an investigation to see whether exam standards have fallen since GCSEs were introduced in 1986. And in 2001 similar statements were made following the publication of the results. This time, according to the Institute of Directors the rising pass rates were "symptomatic of endemic and rampant grade inflation" and showed that the A-level results had been dumbed down. The five A-level boards in England, Wales and Northern Ireland rejection this allegation, saying that comparability studies, the use of archived scripts from previous years and rigorous marking ensured that standards were being maintained. In 2002 the Institute of Directors yet again repeated their concerns and Ruth Lea stated "…yet another 'record breaking year' for A level pass rates is symptomatic of endemic and rampant grade inflation. We must ask ourselves what do we want from A levels since it is clear that they are becoming increasingly meaningless", Press Release, 14 August 2002, http://www.iod.com

29 On this see editorial "The Times", 19 August 1999. There is also evidence presented that it is more difficult to achieve a higher grade at A-level in mathematics and the sciences than in other subjects in "Review of Qualifications for 16-19 Year Olds", Dearing R, Schools Curriculum Assessment Authority (SCAA), 1996.

30 "Measuring the Mathematics Problem", Engineering Council, June 2000, http://www.engc.org.uk/publications/pdf/mathsreport.pdf

31 See "The Maths We Need Now: Demands, deficits and remedies", Bedford Way Papers, Institute of Education, University of London 2000, page 18 for this data. And elsewhere for other issues arising in the teaching of Mathematics in the United Kingdom.

32 "The Maths We Need Now: Demands, deficits and remedies", Bedford Way Papers, Institute of Education, University of London 2000, see page 15.

33 "The Maths We Need Now: Demands, deficits and remedies", Bedford Way Papers, Institute of Education, University of London 2000, see pages 14 - 17.

34 DfEE/DfES models of teacher supply requirements are used to set targets for initial teacher training (ITT). These targets are then used by the Teacher Training Agency (TTA) in planning and funding courses. The Secondary Teacher Supply Model accommodates several factors affecting the number of Mathematical teachers required, including distributions of pupils of different ages, curriculum changes, the perceived amount of time to be allocated to Mathematics, and the inflow and outflow of teachers prior to retirement age.

35 Teacher Training Authority, Annual Report, 1999.

36 The Engineering Council at the time welcomed this development. But the Government announced plans at the end of 1999 for Design and Technology to become one of seven subjects in the National Curriculum to be eligible for "disapplication" - the option to drop Design and Technology at Key Sage 4 (14 - 16 years old).

37 The "golden hello" scheme was also changed to take this development into account. Thus if someone is applying this year for a postgraduate initial teacher training course and that this person would have been eligible for an old-style "golden hello", then he or she can choose whether to receive up to £5,000 under the old scheme (split between training and then starting a post) or up to £10,000 per year in training salary and a new-style "golden hello" of £4,000 at the beginning of the second year of teaching. Also see page 54 in "SET for success: the supply of people with science, technology, engineering and mathematical skills", Report for the Chancellor of the Exchequer, April 2002. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm

38 Professor Alan Smithers of Liverpool University, one of the country's leading experts on teacher supply, believes not only that the government has recognised the scale of the problem rather belatedly but that it is a more serious crisis than the last to occur in the 1980's. He believes that this crisis was solved both by the expansion of training places and the collapse of the Lawson boom of the late 1980's and the recession that followed. Rising unemployment and insecurity in other professions simply made teaching seem more attractive. When the economic boom in the 1990’s got underway, the old problems re-emerged. Professor Smithers has said "The Government has to tackle the fundamentals. That means looking at salaries and the amount of money that schools are getting. Working conditions need to be improved so that teachers can concentrate on teaching rather than being constantly hassled". However, in September 2000 the then Standards Minister Estelle Morris said that "We are beginning to see significantly increased applications for trainees in secondary school teaching applications, particularly in those subjects as a result of the new £6,000 training salaries and £4,000 golden hellos which we have introduced". But some people have also since argued that the increased applications are not being transmitted into target acceptances for such shortage subjects such as mathematics and technology. Meanwhile the government still insists that talk of a national teacher recruitment shortage is "unduly alarmist". The Schools Standards Minister, DfES, was also stated as saying "We should have, I think, all the teachers we need by September". But Mike Tomlinson, Chief Inspector of Schools, said at the end of August 2001 that "the situation ahead of next week's start to the new term was the worst for 36 years". The truth probably lies some where in between. For government statistics available in 2002 revealed that teaching vacancies in April 2001 were 1.4% of total teaching posts in classrooms in England. This vacancy figure, as it happens, is exactly that for the whole economy - in June 2002 "Labour Market Trends" reported 338,000 unfilled vacancies at Job Centres at that time, or 1.4% of the total labour force employed. However higher vacancy/post ratios than this are found in certain areas, including parts of London such as Southwark, Hackney and Camden.

39 "A Good Start - But is it Enough? A look at recruitment to Mathematics and IT courses since the introduction of golden hellos and training grants", John Howson, Oxford Brookes University & Education Data Surveys, Mimeograph, October 2001. This paper argues that the evidence from the first full year of grants seems positive, at least as far as applications are concerned. But there remain problems. For example many teachers will reach retirement age during the next ten years, so society cannot afford a prolonged period of under recruitment.

40 See Table 2.4, page 54, “SET for success: the supply of people with science, technology, engineering and mathematical skills”, Report for the Chancellor of the Exchequer, April 2002. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index,

41 “Secondary Schools Curriculum and Staffing Survey”, November 2002 (provisional), SFR25/2003. DfES, September 2003, England, http://www.dfes.gov.uk/rsgateway/DB/SFR/s000413/sfr25-2003.pdf See Table 7, Highest post A level qualification held by full time teachers in the subjects they teach to year groups 7 – 13 (provisional). Where a teacher has more than one post A level qualification in the same subject, the qualification level is determined by the highest level reading from left (Degree) to right (Other). For examples teachers shown under a PGCE have a PGCE but not a degree or BEd in the subject, while those with a PGCE and a degree are shown only under a Degree.

42 “School Teachers’ Review Body”, Twelfth Report 2003, Chaired by Bill Cockburn, Cm. 7515. See Tables 16 and 17.

43 “Secondary Schools Curriculum and Staffing Survey”, November 2002 (provisional), SFR25/2003, DfES, September 2003, England. See Table 5, Full time teachers’ age by subject of highest post A level qualification (provisional. Teachers were counted once against each subject that they were teaching.

44 Excellent and wide ranging gender statistics in Science, Engineering and Technology (SET) can be found on the web site of the Office for Science and Technology compiled by the Promoting SET for Women Unit and found at http://www2.set4women.gov.uk/set4women/statistics/index.htm

45 Further Education (FE) was re-defined as a result of the Further and Higher Education Act of 1992. FE colleges changed from being largely Local Education Authority foundations to independent corporations funded mainly, but not entirely, by the Further Education Funding Council (FEFC) (in England only; separate and differing arrangements applied to Northern Ireland, Scotland and Wales). FE was more broadly defined by Schedule 2 of the 1992 Act, most noticeably embracing the work of those Sixth Form Colleges and Community Colleges that are independent of a statutory-age school. FE caters for an enormous diversity of education and training provision, across all ages from 16+.

In mid-1997, it was possible to claim Schedule 2 funding for courses leading to 17,475 different qualifications, of which about one quarter were related to engineering. Approximately one third of these qualifications were approved vocational qualifications (Schedule 2a) and about one half were varieties of GCE and GCSE (Schedule 2b). At the same time 45% of enrolments were on courses leading to approved Vocational Qualifications (VQs) (1,120,522 students) and 37% of enrolments (922,207 students) were on the GCE A-level/GCSE type of programme (FEFC, The Policy Context for the New System of Recording Qualifications, July 1997).

46 Funding arrangements in the past have caused difficulties in obtaining reliable and timely statistics. Until quite recently school sixth forms and adult education were still funded through the LEAs drawing on the Council Tax, supplemented by a block grant from Central Government. There was also a tariff based FEFC funding for FE colleges, Sixth Form Colleges and other providers. Work based training was funded via the Training and Enterprise Councils (TECs). These funding arrangements also led to funding anomalies. For example NVQs provided in the same college were funded differently by the FEFC and TEC. Also Advanced Modern Apprenticeships were jointly funded by the TEC and FEFC and there was a confused boundary between FEFC funded Schedule 2 qualifications and non-Schedule 2 adult courses funded by the LEAs. This particularly affected the formation of Engineering Technician registrants.

47 In 1995, the funding of part-time further education, for those age 16 and 17 and in any form of employment (including Youth Training and Modern Apprenticeship), was transferred from FEFC to the Training and Enterprise Councils (TECs). However, it was possible to fund units leading to FEFC-eligible qualifications that a TEC has specifically said that it will not fund. Unlike the FEFC, there was not a standard methodology applying to TEC funding or data collection. The Learning and Skills Act, which became law on the 28th July 2000, put into effect the government's plans (announced in the White Paper “Learning to Succeed”, June 1999, Cmd 4392, the Stationery Office), to set up a Learning and Skills Council (LSC) for England, http://www.lsc.gov.uk to take charge of the delivery of post-16 education and training (excluding Higher Education). The White Paper set out a new framework to bring together, for the first time, this whole section of post-16 education and training into a single planning and funding system. The Learning and Skills Council replaced the Further Education Funding Council and the Training and Enterprise Councils on 1st April 2001 and assumed responsibility for: funding further education programmes in colleges (from the Further Education Funding Council for England); funding school sixth forms, from April 2002, through the local education authorities; funding Advanced Modern Apprenticeships, Modern Apprenticeships and other government funded Training and workforce development (from Training and Enterprise Councils (TECs); developing, in partnership with local education authorities (LEAs), arrangements for adult and community learning; working with the pre-16 education sector to ensure coherence across all 14-19 education.

The stated aims of the LCS are to provide a more coherent planning and funding system, and higher quality learning opportunities which focus more sharply on the economy's need for skills. The Council operates through 47 local Learning and Skills Councils responsible for managing and developing the local provider infrastructure and planning to meet the Government's National Learning Targets. There are 12 members of the National Council, chaired by Bryan Sanderson; the Chief Executive is now Mark Hayson, who replaced John Harwood who retired in September 2003, http://www.lsc.gov.uk/National/Media/PressReleases/Newchiefexecutive.htm

48 The latest report on the nature and scale of engineering course provision in FE colleges was “Engineering Programme area Review, Further Education Funding Council (FEFC), 2000, http://lsc.wwt.co.uk/documents/inspectionreports/pubs_insp/engpar.pdf , until the publication in September 2003 by the Adult Learning Inspectorate (ALI) of “Engineering, manufacturing and technology in adult learning”, Adult Learning Inspectorate, September 2003, http://www.ali.gov.uk/survey/htm/01/01.01.htm See also http://docs.ali.gov.uk/publications/Retentionachievementrates03030912150804.pdf for “Retention and Achievement Data from Work-Based Learning Inspections”, Adult Learning Inspectorate, August 2003, and “College and Area-wide Inspections”, Adult Learning Inspectorate (ALI) and Office for Standards in Education (Ofsted), HMI 1452, April 2003, http://www.ofsted.gov.uk/publications/docs/3239.pdf

49 DfEE News, PN 64/00, 15 February 2000, "Radical changes will prepare higher education for the 21st century - Blunkett", www.dfee.gov.uk/news/news.cfm?PR-_ID=669 "We…intend to create new two-year Foundation Degrees to help meet our objective that half of all young people benefit from higher education by the age of 30".

50 "Students in UK Higher Education Institutions, 2001/02", HESA, 2003.

51 "SET for success: the supply of people with science, technology, engineering and mathematical skills", Report for the Chancellor of the Exchequer, April 2002, pages 454 & 46, Figure 2.9 1.3. These figures appear to be England only; also the level of awards being made in these figures is not made clear. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk /documents/enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm

52 DfEE News, PN 65/00, 16 February 2000, "Blunkett announces major expansion and reforms of vocational learning", http://www.dfee.gov.uk/news/news.cfm?PR_ID=672

53 DfEE News, PN 313/00, 6 July 2000, New vocational GCSEs to raise standards: Blunkett", http://www.dfee.gov.uk/news/news.cfm?PR_ID=909

54 "Statistics of Education: Vocational Qualifications in the UK: 2001/02", Issue No 02/03, June 2003, National Statistics Bulletin, DfES, to be found at http://www.dfes.gov.uk/rsgateway/DB/SBU/b000398/stats_voc_final.pdf

55 "Engineering, National Report from the Inspectorate, 1999-00", Further Education Funding Council, 2000, http://lsc.wwt.co.uk/documents/inspectionreports/pubs_insp/engin_nr.pdf ,and a separate report, specifically dealing with quality, retention achievement and curriculum issues in engineering provision, from "Engineering Programme Area Review", Further Education Funding Council (FEFC), 2000, http://lsc.wwt.co.uk/documents/inspectionreports/pubs_insp/engpar.pdf.

56 For details of the requirements for the Advanced Modern Apprenticeship in Engineering please see "The Advanced Modern Apprenticeship on Engineering", for use in England and Wales, issue 7, revised 1 September 2003, developed by SEMTA on behalf of the engineering industry, found at http://www.semta.org.uk/semta.nsf/?Open Details of other Advanced Modern Apprenticeships for Pharmacy Technicians, Laboratory Technicians Working in Education and Optical Manufacturing Technicians can also be found here. Details of the Foundation Modern Apprenticeships can also be found at http://www.semta.org.uk/semta.nsf/?Open

57 "Statistical First Release", DfES, SFR 14/2002 published in June 2002, "Government supported work based learning for young people in England 2001-02; Volumes and outcomes, 20 June 2002, DfES. See also "Statistical First Release", DfES, SFR 38/2001, published on 21 September 2001. The proportion of females on these courses remained very low, at between 1% - 3%. Similar figures were recorded for the previous year; see "Statistical First Release", DfEE, SFR 37/2000, published on 22 September 2000.

58 See Table 4: Success rates by programme type and age group 2001/02 and Table 2a: Success rates in all FE institutions by notional level, broad qualification type, qualification and expected end year, 2001/02, Statistical First Release ISR/SFR25, 24 July 2003, Learning and Skills Council, http://www.dfes.gov.uk/rsgateway/DB/SFR/s000404/index.shtml

59 This seems to reflect the general situation in the UK. To quote Steedman "In Britain no reliable estimates are available to show how many of those who start on a Modern Apprenticeship gain the full qualification (NVQ 3 and Key Skills qualification). But figures showing proportions of apprentices gaining any full NVQ qualification (at Level 2 or 3) reveal that only two thirds gained any full NVQ qualification; just under a half gained as NVQ 3. However, this success rate, low as it is in comparison with other countries, is considerably higher than for all young people who embark on a NVQ 3 in apprenticeship, part-time or full-time education. In 1997/98 just under a fifth of all 16-18 year olds who were enrolled for an NVQ course at Levels 3 or 4 successfully obtained the certificate aimed for", see "Benchmarking Apprenticeship: UK and Continental Europe Compared", Steedman H, Centre for Economic Performance, London School of Economics, September 2001, http://cep.lse.ac.uk; the quote is from page 27 of the report, see http://cep.lse.ac.uk/pubs/download/dp0513.pdf.

60 "Benchmarking Apprenticeship: UK and Continental Europe Compared", Steedman H, Centre for Economic Performance, London School of Economics, September 2001, http://cep.lse.ac.uk; the quote is from page 35 of the report, see http://cep.lse.ac.uk/pubs/download/dp0513.pdf.

61 "College and Area-wide Inspections", Adult Learning Inspectorate (ALI) and Office for Standards in Education (Ofsted), HMI 1452, April 2003, http://www.ofsted.gov.uk/publications/docs/3239.pdf

62 "Engineering, manufacturing and technology in adult learning", Adult Learning Inspectorate, September 2003, http://www.ali.gov.uk/survey/htm/01/01.01.htm This quotation can be found in the Executive Summary. In compiling this report, a team of four full-time inspectors examined the findings of 231 inspections carried out between April 2001 and December 2002. The providers inspected had more then 28,000 learners in engineering, technology and manufacturing. The ALI inspects work-based learning funded by the Learning and Skills Council, such as work-based learning for young people and adult and community learning provision. The ALI also inspects work-based learning for the over-18s in colleges, and education and training in prisons. Around 80% of learners in colleges were aged over 18.

63 "Engineering Programme Area Review", Further Education Funding Council (FEFC), 2000, page 4, http://lsc.wwt.co.uk/documents/inspectionreports/pubs_insp/engpar.pdf.

64 "Government supported further education and work based learning for young people on 1 November 2002 – volumes", Statistical First Release, ILR/SFR01, Learning and Skills Council, 31 March 2003, http://www.dfes.gov.uk/rsgateway/DB/SFR/s000386/LSCILRSFR01r131Mar03.pdf

65 There are two principal sources of statistical information concerning applications to and participation in higher education. The Universities and Colleges Admissions Service (UCAS) handles applications from UK and overseas applicants to degree courses at over 100 Universities in the UK (before 1994 this role was carried out by two separate agencies, UCCA for the universities and PCAS for the polytechnics). The Higher Education Statistics Agency (HESA), established in 1993, collects data on all aspects of higher education, including the student population, directly from the universities.

66 However there was a slight fall from 276,503 to 272,340 in 1998, brought about by a continuing decline in mature students. 80% of entrants to all undergraduate degree courses and 82.5% to Engineering are under 21 years of age, according to the 1998 UCAS Report. However the position is reversed to 72% and 68% respectively if HESA figures are used. HESA figures include part-time attendees who tend to be over 21.

67 The term 'Computing' is used here to refer to the following UCAS subjects: G5 Computer Science, G6 Computer Systems Engineering, G7 Software Engineering and G8 Artificial Intelligence. HESA uses only one category, 'Computer Science'.

68 UCAS Figures for acceptances of home students undercounts the actual number on Engineering courses. HESA data for the academic year 1997 suggests that about 4,000 more enter engineering courses that the UCAS figures indicate. Part of this difference is due to the addition of 2,256 part-time undergraduate students attending engineering courses. Another reason for the difference is the number of HND students who move on to a first degree within the same university and who therefore would not be recorded in the UCAS figures.

69 Computer Science and related subjects are acceptable as an academic base for registration as a professional engineer. Courses are accredited by the British Computer Society and the Institution of Electrical Engineers.

70 In 2001 77% of students, who were accepted to engineering course with A/AS levels only, entered with A level Maths. The corresponding figure for Physics was also 77%. See pages 39 & 40, "The Graduate Survey 2001", Collective Enterprises Ltd., 2002, for the DTI with Barclays Bank. Also engineers and electrical engineers scored higher than average A level points than those in the whole sample, i.e. all graduates. And 46% of engineers and 57% of electrical engineers scored 24 points or more.

71 "International Comparisons of HE Entrance Requirements for Computer Science and Engineering Graduates: UK", Hansen K, Vignoles A, Centre for Economic Performance, London School of Economics, January 2000, see pages 20-21 http://cee.lse.ac.uk/Related%20Reserach%20Papers/CEERRP5.pdf.

72 "Degree Course Offers", Heap B, Trotman: Surrey, UK, 1999.

73 Source: "Statistical Focus" Volume 2, Issue1, summer 2000, HESA. And "Students in Higher Education Institutions 2000/01", HESA 2002.

74 Note on UCAS course codes used: Biological Sciences consists of all the C codes except C6 Sports Science in 2002 and 2003, Sports Science being classified here for the first time in 2002; Mathematics and Physical Sciences are defined as all the F codes plus G0, G1, G2 and G3 and their predecessors; Computer Science is defined here as codes G4, G5, G6 and G7 (and their predecessors); and Engineering and Technology consist of all the H codes and all the J codes.

75 "Performance indicators in higher education in the UK", 1996-97, 1997-98, December 1999/66, Higher Education Funding Council for England (HEFC). See also "Performance indicators in higher education in the UK", 1997-98,1998-99, October 00/40, HEFC and 1998-99, 1999-2000, December 01/69, http://www.hefce.ac.uk/research And "Performance indicators in higher education in the UK", 1999-2000, 2000-01, December 2002/52, http://www.hefce.ac.uk/Learning/perfind/2002/annad.asp and see Table B9. And "Performance Indicators in higher education in the UK, 2000-02, 2001-02, December 2003/59, http://www.hefce.ac.uk/learning/perfind/2003/default.asp

76 "Performance indicators in higher education in the UK", 1996-97, 1997-98, December 1999/66, Higher Education Funding Council for England (HEFC). See also "Performance indicators in higher education in the UK", 1997-98, 1998-99, October 00/40, HEFC and 1998-99, 1999-2000, December 01/69, http://www.hefce.ac.uk/research and see Table B13.

77 See "Performance indicators in higher education in the UK", 1999-2000, 2000-01, December 2002/52, http://www.hefce.ac.uk/Learning/perfind/2002/annad.asp and see Table B9. And "Performance Indicators in higher education in the UK, 2000-02, 2001-02, December 2003/59, http://www.hefce.ac.uk/learning/perfind/2003/default.asp

78 "Performance Indicators in higher education in the UK, 2000-02, 2001-02, December 2003/59, http://www.hefce.ac.uk/learning/perfind/2003/default.asp table B9.

79 See "Times Higher Education Supplement", December 3 1999, "Tables for our times", Bahram Bekhradnia, Director of Policy, Higher Education Funding Council for England (HEFC). This is in fact a projection found in "Performance Indicators in Higher Education", reference 45. See page 11 where it states that "Nationally, 80% of students are projected to obtain a degree eventually, perhaps having transferred institutions en route, and a further 2% to obtain a different qualification. 18 per cent are expected to discontinue their studies and not resume at any UK HEI. They are assumed to have gained no qualifications". This figure was calculated on the basis of the sector projected outcomes of the 1996 intake of students but a very similar figure was found a year later on the basis of the 1997 intake. Projections are made as it is considered impractical by the writers of the report to track a cohort of students completely through the HE system. This is because of the time involved and the fact that at present there are not reliable records going back far enough (see paragraph 50, page 7, October 00/40 Report). The projections are made on the assumption that students will move through the HE system in the future in the same way as they do currently. These projections are made for all HE institutions (and not by subject).

80 "Students in Higher Education Institutions", 1994/95, 1997/98, 2001/02, Higher Education Statistics Agency (HESA).

81 At the end of 2003, SARTOR was superseded by the UK Standard for Professional Engineering Competence (UK-SPEC). It differs from SARTOR in several respects, with its emphasis on competence irrespective of route, and removal of the direct link to A-level grades. In the publication UK-Spec, it is stated that formal education is the usual, though not the only way of demonstrating the underpinning knowledge and understanding for professional competence. See http://www.uk-spec.org.uk

82 National Science Board, "Science and Engineering Indicators - 2002". Arlington, VA, USA: National Science Foundation, 2002. This excellent publication is available on http://www.nsf.gov/sbe/srs/seind02/pdfstart.htm See e.g. Appendix table 2-34.

83 It should be borne in mind, however, that data on numbers of graduates do not necessarily correlate with numbers employed as professional scientists and engineers. Rather, they should be viewed as giving some indication of the skill resource available to the country concerned.

84 The EU states are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the UK. Luxembourg is not included, as only the first year of university studies can be undertaken there; students then move to foreign countries.

85 In Russia, it would seem that the number of students studying engineering subjects is "more than 35% of the general number of students in the country", source, Russian Association of Engineering Education, 2003.

86 "New approaches to the Education and Qualification of Engineering: Challenged and Solutions from a Transatlantic Perspective", Federal Ministry of Education and Research, June 1999 and British Embassy, Bonn Office, May 2001. In 1996 some 52,000 engineers graduated per annum. By 1998 the number had fallen to 40,000, by 2000 to under 35,000 and by the year 2002 it is projected to decline to 31,000 per annum. However, the number of engineering graduates is expected to increase modestly to an estimated 34,800 by 2004.

87 These statistics are from "Engineering and Technology Degrees, 2002", the Engineering Workforce Commission's annual survey, http://www.aaes.org The statistics also show that in fields such as computer science and engineering, almost half of the graduate population is foreign born. Over the summer of 2003, top government advisory groups were going to offer their analyses of the situation. See http://www.sciencemag.org Also see "Science and Engineering Indicators 2002", Appendix table 2-33, "Bachelors S&E degrees in the United States and Asia, by field: 1975 – 98 (selected years", http://www.nsf.gov/sbe/srs/seind02/pdfstart.htm

88 In Europe the Bologna Declaration commits the UK and most other European countries to move towards the 2 cycle system.

89 "SET for Success: the supply of people with science, technology, engineering and mathematical skills", Report for the Chancellor of the Exchequer, April 2002, pages 138 - 139, Figure 4.9. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk/documents /enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm

90 National Science Foundation/SRS, Survey of earned doctorates for the years 1991-1995

91 Science and Engineering Indicators 2002, National Science Foundation, Appendix table 2.35, http://www.nsf.gov/sbe/srs/seind02/pdfstart.htm

92 See "Student Fees – Their impact on Student Decision Making and Institutional Behaviour" for an assessment of the likely effect of the introduction student loans and tuition fees in the UK and which based on the earlier experience of New Zealand, published by HEIST Marketing Services, 1999. The Dearing Report published in 1997 suggested a (maximum) fee of £1,000 to be applied on a means test basis. When introduced in autumn 1998 this fee was indexed to the rate of inflation and therefore was £1,075 in 2001/02 and about £1,100 and in 2002. Following the publication of the Cubie Report in 1999, all Scottish Universities charge no fee for students from Scotland although those from elsewhere in the UK do pay. However the tuition costs are recovered later from the Scottish students via their future income, in the way already undertaken for student loans using an income contingent loan scheme. There is increasing discussion regarding the application of higher and differential student fees. See "Funding Universities to Meet National and International Challenges", Greenway D, Haynes M, University of Nottingham, http://www.nottingham.ac.uk/economics/funding or http://www.nottingham.ac.uk/economics/funding/funding.pdf In this report it is proposed that engineering undergraduates pay fees of (about) £2,000 per annum compared to £1,000 for philosophy and £4,500 for medicine and dentistry courses. The subject of differential tuition fees, however, remains controversial and frequently discussed. See "Study deal to take sting out of fees hike", Times Higher Educational Supplement, 12 July 2002, where journalist Claire Sanders states that "Cut-price charges for foundation degrees are being considered to sweeten the pill of introducing differential fees and to help universities to meet the government's expansion targets. A government decision was taken in 2003 to introduce differential tuition fees in the Autumn 2006 and the Bill to introduce differential fees that are to be recoverable later narrowly passed in the House of Commons in February 2004. Measures in the Bill included the allowance for reduced fees or no fees to be applied to people from poorer families and it is intended that loans be available on income-contingent basis with no real rate of interest to allow students to defer payment of fees in cases where they have to be paid; and also after 25 years all outstanding debt that any individuals have will be abolished, see http://www.publications.parliament.uk/pa/cm200304/cmbills/035/2004035.htm and http://www.dfes.gov.uk/hegateway/uploads/Higher%20Education%20Bill%20Explanatory%20Notes.pdf However, the Conservative Party pledged in the Spring of 2003 to not introduce them and to abolish differential fees if they are ever introduced.

93 Source: "Research into First Destination of 2000 Graduates", Collective Enterprises Ltd., 2001, for the DTI in partnership with Barclays Bank. For data on student debt see pages 53 and 54.

94 See "Graduate Recruiter", Association of Graduate Recruiters (AGR), April 2003.

95 "Recruitment and Retention in Employment in UK Higher Education"; IRS Research report, CVCP; OME report, UCEA; published February 2000. This was partly an up-date of the "Bett Report" published in June 1999 ("Independent Review of Higher Education Pay and Conditions", HMSO).

96 "SET for success: the supply of people with science, technology, engineering and mathematical skills", Report for the Chancellor of the Exchequer, April 2002. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/research_and _enterprise/ent_res_roberts.cfm See pages 117-120, Figure 4.4 and Table 4.1.

97 "First Destination of Students Leaving Higher Education Institutions, 2000/01", Higher Education Statistics Agency (HESA), 2002 and "First Destination of Students Leaving Higher Education Institutions, 2001/02", Higher Education Statistics Agency (HESA), 2003.

98 Page 70, "Moving On, Graduate Careers Three Years After Graduation", November 1999, DfEE and obtainable from CSU Ltd., Manchester, telephone: 0161 277 5200 or http://www.warwick.ac.uk/ier

99 SOC 90 is used here. However the details of SOC 2000 were published in 2000 and this version will be used in the future.

100 As far as computer professionals are concerned, the SOC 1990 identifies 'software engineers' as professionals and 'computer analyst/programmers' as associate professionals. The SOC 2000, published in 2000, has resolved this and some other problems.

101 "2002 Graduate Salaries and Vacancies Half Yearly Review", July 2002. Also "AGR Graduate Recruitment Survey 2003, Winter and Summer Review", High Fliers Research Limited. As the companies involved are mostly large and "traditional" graduate employers, then the average and median salaries calculated for the AGR are found to be consistently higher than those found in surveys of the wider graduate population.

102 Source: "The Graduate Survey 2001", Collective Enterprises Ltd., April 2002 and "The Graduate Experience 2002 Report, March 2003, for the DTI in partnership with Barclays Bank.

103 The degrees specified were: Chemistry, Physics, Materials Science, Environmental Science, Pollution Control, Mathematics & Statistics, Electronic/Electrical Engineering, Chemical Engineering, Production/Manufacturing Engineering, Electro-mechanical Engineering, Mechatronics and any combination of these.

104 "What Do Graduates Really Do?", Connor H, Pollard E, Institute of Employment Studies, report 308, 1996, http://www.employment-studies.co.uk

105 "What Do Graduates Do Next?", Connor H, La Valle I, Pollard E, Millimore B, Institute of Employment Studies, Report 343, 1997, http://www.employment-studies.co.uk

106 "Moving On, Graduate Careers Three Years After Graduation", November 1999, DfEE and obtainable from CSU Ltd., Manchester, telephone: 0161 277 5200 or http://www.warwick.ac.uk/ier

107 "Performance Indicators in Higher Education, 1996-97, 1997-98", December 99/66, Higher Education Funding Council for England (HEFCE). Also see http://www.hefce.ac.uk/research

108 In "Moving On" traditional graduate occupations were defined as occupations were employees typically have 5 years of additional education after the age of compulsory schooling and a minimum of 4 years. In graduate track occupations the employees typically have 3 years of additional education and a minimum of 2.5 years. Non-graduate occupations have employees who typically had 1.5 years of additional education.

109 "The National Graduate Tracking Survey 2000", Collective Enterprises Limited, March 2000.

110 "The National Graduate Tracking Survey 2001", Collective Enterprises Limited, July 2001and "The National Graduate Tracking Survey 2002", Collective Enterprises Limited, July 2002

111 "Graduate Tracking Survey 2003, Collective Enterprises Limited; however, all the data described here was extracted from a presentation given by its Chief Executive, Kenneth Spencer, in December 2003.

112 See also and recent, "The Return to Higher Education in Britain: Evidence from a British Cohort", Blundell R, Dearden L, Goodman A, Reed H, The Economic Journal, 100, February 2000, pages F82 – F99. And "Graduate Employability: Policy and Performance in Higher Education in the UK", Smith J, McKnight A, Taylor R, The Economic Journal, 110, June 2000, pages F382 – F411. And finally, "Occupational Earnings of Graduates: Evidence for the 1993 UK University Population", Naylor R, Smith J, Mcknight A, March 2000, Department of Economics, University of Warwick and also available on: http://www.warwick.ac.uk/fac/soc/Economics/research/publicpolicy.html or http://www.warwick.ac.uk/staff/Robin.Naylor/research/conferences.htm Also see http://www.warwick.ac.uk/fac/soc/Economics/jeremysmith/res2000.pdf

113 "Education, earnings and productivity: recent UK evidence", Walker I, Zhu Y, National Statistics "Labour Market Trends", March 2003, Volume 111, No:3. Those excluded from the analyse were those living in Scotland (which has a quite different education system from England and Wales), those with zero or missing hours of work or earnings, immigrants (who will have been mostly educated outside of the UK) and those aged below 25 and above 59. This paper also finds no evidence that the recent expansion of higher education has resulted in financial returns falling, implying that the expansion of supply is just keeping up with growing demand. They also show that the effect of education on wages and earnings does work via higher productivity, refuting the argument that more productive people choose to get more education so as to distinguish themselves form the less productive in the eyes of employers (the so-called "signalling argument")

114 The Engineering Council's 35 Licensed Members at the time of publication are listed on the EC (UK) web site at http://www.engc.org.uk/registration/inst_addresses.asp And the 14 Professional Affiliates can be found at http://www.engc.org.uk/registration/professional_affiliates.asp

115 From September 1997 the education requirements for registration in the Council's Standards and Routes to Registration (SARTOR), 3rd Edition were as follows: four years' academic study for Chartered Engineers instead of three as the educational base. The requirement met by a 4-year accredited MEng degree or equally by a 3-year accredited BEng (Hons) degree plus a 'Matching Section' three years' academic study for Incorporated Engineers instead of two as the educational base. The requirement met by a 3-year accredited IEng degree or equally by a 2-year HND plus a 'Matching Section' the use of entry standards as criteria for accreditation of MEng, BEng (Hons) and IEng degree courses in order to ensure a cohort of sufficient intellectual capability to support a high standard of course content. (These requirements were "ramped-in" over four years from 1999). And see http://www.ukspec.org.uk/sartor/index.asp

At the end of 2003, SARTOR was superseded by the UK Standard for Professional Engineering Competence (UK-SPEC). It differs from SARTOR in several respects, with its emphasis on competence irrespective of route, and removal of the direct link to A-level grades. It is also employer focused and emphasises the importance of the Engineering Technician. And it embraces changes that have taken place in the education system in recent years. See http://www.ukspec.org.uk/faq/faq_uk.asp And see http://www.engc.org.uk/registration on how to register and http://www.ukspec.org.uk for full details of UK-SPEC.

116 Not very different from the 219,444 (which includes some duplication) recorded by the Report of the Committee of Inquiry into the Engineering Profession, "Engineering Our Future", (Finniston Inquiry) in 1980, HMSO, January 1980, Cmnd. 7794.

117 See Appendix One in the report "Early Career Experiences of Engineering and Technology Graduates", Canny A, Davis D, Elias P, Hogart T, February 2002, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment Research (IER). This report was subsequently up-dated; it was published in June 2003 and can be found at http://www.etechb.co.uk/archive/EarlyCareerExperiencesfinalreport.pdf However, some changes were made in the both the classifications of the occupations considered and the definitions of the degrees of employees. As regards the later report science degree holders were included in the up-date but not in the first report, so some of the figures in the two reports cannot be directly compared.

118 The 2003 Survey of Registered Engineers prepared for the Engineering and Technology Board can be found at http://www.etechb.co.uk/archive/2003_Survey.pdf This survey also found that 75% of registrants would recommend registration to a colleague, 47% stated that their employer paid their subscription and registration fees, 57% said that their employer offered financial support for their professional development and reasons for becoming an Incorporated Engineer or Engineering Technician were sought (question 13, page 36).

119 "Standard Occupational Classification 2000, Vol. 1 & Vol. 2", Office for National Statistics, Crown Copyright 2000. The New Earnings Survey is an annual 1% sample of the employed population where individuals' pay details are gathered from their employers.

120 Surveys of their Members by individual Nominated Bodies substantiate this conclusion; for example, the Institution of Electrical Engineers' Salary Survey 2000 found that the median salary of IEE full Members was £37,500 and that for Chartered Engineers was £42,140. Likewise, the 2000 Institution of Chemical Engineers Salary Survey gave IChemE Fellows' and Members' median income as £42,800, the Institution of Civil Engineers' 1998 Salary Survey indicated that the median salary for Chartered Civil Engineers was £32,000 and the Institution of Mechanical Engineers' 1999 Salary Survey recorded a median salary for Chartered Engineers of £37,852. Average and median earnings for members of the Institution of Civil Engineers over the year to April 2002 were £46,792 and £37,500 respectively as reported by the Institution of Civil Engineers and New Civil Engineer Salary Survey 2002, http://www.nceplus.co.uk Also the 2002 Institution of Chemical Engineers Salary Survey gave Corporate Members' average income as £51,792; the median for Corporate Members was £46,100. One of the reasons why the Engineering Council and Engineering and Technology Board figures are higher than their apparent ONS equivalent is because the former include a number of senior company managers who will be classified as such in the ONS figures and will not appear as a professional engineer (in major group 2 and code 21) but as a senior manager (in major group 1). Another reason is that it takes time to register as an engineer, so there are proportionately younger engineers in the ONS figures than there are amongst working registered engineers.

121 The response rate to the 2002 Survey was excellent at 39.8% compared to 34.2% in the 2001 Survey. And in 1999, 2000 and 2001 key aspects of the structure of the sample mirrored that of the population data. The proportion of respondents by grade of registration and the proportion of registrants found by age bands in the sample reflects almost exactly these aspects of the population found in our own registrant database. "Survey of Registered Engineers 2002", Engineering Council (UK), 2002, http://www.engc.org.uk/who_we_are/fullreport.pdf The response rate in the Engineering and Technology Board 2003 Survey of Registered Engineers was lower at 29.6%; this is almost certainly due to the fact that the survey took place later than usual and in August when a number of registered engineers must have been away on their summer holiday. Also "Survey of Professional Engineers and Technicians 1999, Engineering Council, 1999, price £95 and "Survey of Registered Engineers 2001", Engineering Council, 2001, price £95.

122 IDS Management Pay Review, Income Data services, No: 271, September 2003.

123 At the end of 2003, SARTOR was superseded by the UK Standard for Professional Engineering Competence (UK-SPEC). It differs from SARTOR in several respects, with its emphasis on competence irrespective of route, and removal of the direct link to A-level grades. UK-SPEC offers the following definitions of the roles and responsibilities of the three categories of registered engineering professional:

Chartered Engineers are characterised by their ability to develop appropriate solutions to engineering problems, using new or existing technologies, through innovation, creativity and change. They might develop and apply new technologies, promote advanced designs and design methods, introduce new and more efficient production techniques, marketing and construction concepts, pioneer new engineering services and management methods. Chartered Engineers are variously engaged in technical and commercial leadership and possess effective interpersonal skills.

Incorporated Engineers are characterised by their ability to act as exponents of today's technology, through creativity and innovation. To this end, they maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation. Incorporated Engineers are variously engaged in technical and commercial management and possess effective interpersonal skills.

Professional Engineering Technicians are involved in applying proven techniques and procedures to the solution of practical engineering problems. They carry supervisory or technical responsibility, and are competent to exercise creative aptitudes and skills within defined fields of technology. Professional Engineering Technicians contribute to the design, development, manufacture, commissioning, operation or maintenance of products, equipment, processes or services. Professional Engineering Technicians are required to apply safe systems of work. See http://www.uk-spec.org.uk

124 See e.g. "The Labour Market for Engineering, Science, and IT Graduates: Are There Mismatches Between Supply and Demand?", Mason G, National Institute for Economic and Social Research, DfEE Research Report 112, September 1999 and Engineering Skills Formation in Britain: Cyclical and Structural Issues", Skills Task Force Research Paper 7, Mason G, National Institute of Economic and Social Research, September 1999. A full report is available free of charge available from DfES Publications, 0845 602260. Also "SET for success: the supply of people with science, technology, engineering and mathematical skills", Report for the Chancellor of the Exchequer, April 2002. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/research_and_enterprise /ent_res_roberts.cfm See pages 26 – 32 dealing with shortages in the supply of scientists and engineers and which leads to the report's conclusion that there is a "disconnect" between the demand for the skills found in mathematics and the engineering and physical sciences (but not in IT and computer science) and their supply. This disconnect theme or thesis is also pursued in "Building the Stock of Top Quality Engineers Literature Review"", Opinion Leader Research, June 2002, a report commissioned by the Engineering and Technology Board (ETB), pages 10 – 20.

125 "1998 Labour Market Survey of the Engineering Industry in Britain", Engineering and Marine Training Authority (EMTA), RR12A, October 1998, "1999 Labour Market Survey of the Engineering Industry in Britain", Engineering and Marine Training Authority, RR124, November 1999 and "2002 Labour Market Survey of the Engineering Industry In Britain", Engineering and Marine Training Authority, RR152, July 2002.

126 "Early Career Experiences of Engineering and Technology Graduates", Canny A, Davis D, Elias P, Hogart T, June 2003, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment Research (IER). This report can be found at http://www.etechb.co.uk/archive/EarlyCareerExperiencesfinalreport.pdf See pages 15 and 16, section 2.5, and figures 2.13, 2.14 and 2.15, for "Further study or training since graduating", a educational process which many people would describe as part of continuing professional development or CPD.

127 This survey was conducted in the winter of 1998/99, three and a half years after graduation; 9,662 graduates responded to this survey of which 867 (9%) had an engineering degree.

128 The 1999 Labour Force survey was used and all graduates working were selected who were aged 24 to 29 years at the time of the survey.

129 2002 EMTA Labour Market Survey, July 2002.

130 "Engineering Skills Formation in Britain: Cyclical and Structural Issues", Skills Task Force Research Paper 7, Mason G, National Institute of Economic and Social Research, September 1999. A full report is available free of charge available from DfES Publications, 0845 602260

131 "Excellence and Opportunity: a science and innovation policy for the 21st century", DTI White Paper, July 2000. Also available from http://www.dti.gov.uk/ost/aboutost/dtiwhite

132 "Competing in the Global Economy: the innovation challenge", the Innovation Report, DTI, December 2003, see http://www.dti.gov.uk/innovationreport/index.htm or http://www.dti.gov.uk/innovationreport/innovation-report-full.pdf Innovation was defined here simply as "the successful exploitation of new ideas".

133 "Towards a National Skills Agenda. First Report of the National Skills Task Force", DfEE 1998.

134 "An Assessment of Skill Needs in Engineering", Skills Dialogues: Listening to Employers, 2001, DfEE now DfES publications, 2001. See www.skillsbase.dfee.gov.uk/downloads/Engineering_report.pdf or http://www.dfee.gov.uk/skillsforce

135 "Projections of Occupations and Qualifications: 1999/2000", Institute for Employment Research, University of Warwick, Department for Education and Employment, June 2000. See http://www.warwick.ac.uk/ier Hard copies of "Projections of Occupations and Qualifications: 200/2001: Research in Support of the National Skills Taskforce", Wilson RA, Green A E, Sheffield: DfEE and "Projections of Occupations and Qualification: 2000/2001: Regional Results", Wilson R A, Green A E, Sheffield: DfEE, are available free of charge available from DfES Publications, 0845 602260.

136 "Developing Technicians: Phase 1 Report", The Institute for Employment Studies, University of Sussex, Brighton, published by the Engineering and Technology Board, June 2003, see http://www.etechb.co.uk/learning/Docs/Technician_Phase1.pdf and http://www.etechb.co.uk/learning/etb_Technicians_Rep_v.5.pdf

137 "Skills for Manufacturing SMEs: A survey of strategies and requirements", Benchmark Research Limited, published by the Engineering and Technology Board in November 2003, see http://corp.etechb.co.uk/learning/Docs/Skills_for_Manufacturing_SMEs.pdf and summary report http://corp.etechb.co.uk/learning/Docs/Skills_for_Manufacturing_SMEs-summary.pdf. The research was primarily focused on the SME sector within science, engineering and technology industries. For the purpose of this research a SME was defined as a business that employs between 50 and 250 staff and all companies with less than 50 staff were excluded. The main quantitative stage of the research was conducted by telephone during July and August 2003 and 213 telephone interviews were completed.

138 A concept used by Mason in "The Labour Market for Engineering, Science, and IT Graduates: Are There Mismatches Between Supply and Demand?", Mason G, National Institute for Economic and Social Research, DfEE Research Report 112, September 1999 and Engineering Skills Formation in Britain: Cyclical and Structural Issues", Skills Task Force Research Paper 7, Mason G, National Institute of Economic and Social Research, September 1999. A full report is available free of charge available from DfES Publications, 0845 602260

139 "Training provision and the development of small and medium sized enterprises", Research Brief 26 DfEE, October 1997 and "Investment in training and small firm growth and survival: An empirical analysis for the UK 1987-95", Research Brief 36, DfEE, January 1998.

140 "Skills for Manufacturing SMEs: A survey of strategies and requirements", Benchmark Research Limited, published by the Engineering and Technology Board in November 2003, see http://corp.etechb.co.uk/learning/Docs/Skills_for_Manufacturing_SMEs.pdf, pages 26 to 32, and summary report http://corp.etechb.co.uk/learning/Docs/Skills_for_Manufacturing_SMEs-summary.pdf.

141 For more detail see e-skills Bulletin on http://www.e-skills.com/bulletin Also for a European perspective on ICT Skills, see "Information technology Practitioner Skills in Europe, Study of the Labour Market position, particularly for Germany, Ireland, Sweden, and the United Kingdom", Dixon M, Council of European Professional Informatics Societies (CEPIS), May 2002.

142 “International migration and the United Kingdom: Recent patterns and trends”, Dobson J, Koser K, McLaughlan G, Salt J, Final report to the Home Office, December 2001, http://www.homeoffice.gov.uk/rds/pdfs/occ75.pdf

143 Barry R, Bosworth D, Wilson R, "Engineers in Top Management", Institute for Employment Research, University of Warwick, 1997. The study was commissioned by the Engineering Council and the Royal Academy of Engineering.

144 Source document used was "Venture Capital Report Guide 1999", Edited by Angier P, distributed by Financial Times Management, 1999 edition, January 1999.

145 Even statutory registration is unlikely to achieve this: the Engineering Council in the past has estimated that it may at present be achieving voluntary registration of up to 50% of those eligible. Indeed it may well be a good deal less than this.

146 Office for National Statistics (ONS) Labour Force Survey, Spring Quarter, March to May 2001, using SOC2000. The labour Force Survey is a quarterly sample of over 60,000 households and over 120,000 individuals.

147 “SET for success: the supply of people with science, technology, engineering and mathematical skills”, Report for the Chancellor of the Exchequer, April 2002, page 28, Table 1.3. “Average salaries rose by 4.1% in real terms over the period 1994 to 2000. These figures support the views expressed by many employers that there are developing shortages in engineering, mathematics and the physical sciences”. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hmtreasury.gov.uk/documents/enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm

148 This is defined as follows:

SIC code	*Definition*
27	Basic Metal Manufacture
28	Fabricated metal products, except machinery equipment
29	Machinery and equipment no elsewhere classified
30	Office machinery and computers
31	Electrical machinery and apparatus, not elsewhere specified
32	Radio, TV and communications equipment and apparatus
33	Medical, precision and optical instruments, watched and clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment

149 In late 1999 the Science Minister, Lord Sainsbury, invited the Chairman of the Senate of the Engineering Council Dr. Robert Hawley “to review the contribution the Council should make to add value to the engineering community, to the benefit of the UK economy”. The Hawley Review Group and then the Shadow Engineering and Technology Board addressed this task which was based on the premise that the engineering community extends well beyond the commonly recognised boundaries of the profession. It followed that the review would need to explore and define the wider engineering community as a foundation for its further work. For this purpose a joint working group was set up with members nominated by the Royal Academy of Engineering and the Engineering Council reporting in the first instance to the President and the Chairman of these two bodies. Sir Robert Malpas was invited to chair the working group. The resulting report ”The Universe of Engineering - A UK Perspective”, was published by the Royal Academy of Engineering, July 2000, http://www.engc.org.uk/publications/pdf/Malpas_report.pdf

150 “Maximising Returns to Science, Engineering and Technology Careers”, People, Science and Policy Ltd and the Institute for Employment Research, University of Warwick, Report for the OST and DTI, DTI/Pub5884/2k/01/02.NP, January 2002. The single most important finding of this report was that only a minority of SET graduates work in SET occupations as they are defined here. A large pool of female (and male) SET graduates were identified as “potential returners”. See http://www.set4women.gov.uk/set4women/projects/maximising_returns/index.htm

151 “Early Career Experiences of Engineering and Technology Graduates”, Canny A, Davis D, Elias P, Hogart T, February 2002, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment Research (IER). This report was subsequently up-dated; it was published in June 2003 and can be found at http://www.etechb.co.uk/archive/EarlyCareerExperiencesfinalreport.pdf However, some changes were made in both the classifications of the occupations considered and the definitions of the degrees of employees. As regards the later report science degree holders were included in the up-date but not in the first report, so some of the figures in the two reports cannot be directly compared.

152 See page 4, in the report “Early Career Experiences of Engineering and Technology Graduates”, Canny A, Davis D, Elias P, Hogart T, February 2002, a report prepared for the Engineering and Technology Board (ETB) by the Warwick Institute for Employment Research (IER). This report was subsequently up-dated; it was published in June 2003 and can be found at http://www.etechb.co.uk/archive/EarlyCareerExperiencesfinalreport.pdf However, some changes were made in both the classifications of the occupations considered and the definitions of the degrees of employees. As regards the later report science degree holders were included in the up-date but not in the first report, so some of the figures in the two reports cannot be directly compared.

153 "Assessing the Supply and Demand of Scientists and Engineers in Europe", Pearson R, Jagger N, Connor H, Perryman S with de Grip A, Marey P, Corvers F, Report 377, Institute of Employment Studies, February 2001, http://www.employment-studies.co.uk

154 “SET for success: the supply of people with science, technology, engineering and mathematical skills”, Report for the Chancellor of the Exchequer, April 2002. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm

155 “Developing Technicians: Phase 1 Report”, The Institute for Employment Studies, University of Sussex, Brighton, published by the Engineering and Technology Board, June 2003, see http://www.etechb.co.uk/learning/Docs/Technician_Phase1.pdf and http://www.etechb.co.uk/learning/etb_Technicians_Rep_v.5.pdf

156 “The Professional Technologist: A Review”, Institute for Employment Studies, University of Sussex, Brighton, published by the Engineering and Technology Board, July 2003, see http://www.etechb.co.uk/learning/Docs/Technologist.pdf See also “Developing Technicians in the Work Force: Final Report Phase 2”, Questions Answered Limited, published by the Engineering and Technology Board, February 2004, see http://corp.etechb.co.uk/learning/Docs/Developing_Technicians_Synopsis.pdf and http://corp.etechb.co.uk/learning/Docs/Developing_Technicians_in_the_Workforce.pdf. This research was intended to investigate best practice in a range of different sectors to identify those training and development approaches which have the greatest potential for both success in their outcomes, and in transferability across sectors and different working practices. The research focussed primarily on the demand side and the ways in which employers have developed best practice in training and development within their organisations. The overall conclusion of this research is that, while there are many examples of good practice which, of themselves, will reduce the levels of skills shortage and skills gaps and improve the productivity of their businesses, these cases are relatively isolated. However this research had its statistical limitations as it is a small scale survey involving five demonstration projects from five diverse sub-sectors of SET – Aerospace, Automotives, Building Services, IT Support Services and Pharmaceuticals. While each project was benchmarked against a wider sample of similar activity across the whole country, the recommendations are inevitably based on a few specific cases.

157 “The Professional Technologist: A Review”, Institute for Employment Studies, University of Sussex, Brighton, “Technologists Background Data Annex" Jagger N, published by the Engineering and Technology Board, July 2003, paper copies of this annex are available from the Engineering and Technology Board.

158 Excellent and wide ranging gender statistics in Science, Engineering and Technology (SET) can also be found on the web site of the Office for Science and Technology complied by the Promoting SET for Women Unit and found at http://www2.set4women.gov.uk/set4women/statistics/index.htm

159 See Chart 1, page 14, “Construction Skills Foresight Report 2003”, Construction Industry Training Board (CITB), 2003, copy from Linda.gilardoni@citb.co.uk, price £50.

160 “The Social and Economic Value of Construction: the Construction Industry’s Contribution to Sustainable Development 2003”, Pearce D, nCRISP, the Construction Industry Research and Innovation Strategy Panel, 2003. See http://www.crisp-uk.org.uk for the Full Report and an Executive Summary of the Full Report in pdf form. Paper copies can also be obtained from Jennifer Campbell at crisp@davislangdon-uk.com.

161 The report used data from the O’Mahony and De Boer 2002 study which used the ONS definition of construction and not therefore a wide one. See “Britain’s relative productivity performance: Updates to 1999: Final Report to DTI/Treasury/ONS”, O’Mahony M and de Boer W, National Institute of Economic and Social Research, March 2002, http://www.niesr.ac.uk/research/BRPP02.pdf

162 “Innovation and Skills Mix: Chemical Engineering in Britain and Germany”, Mason G and Wagner K, National Institute of Economic and Social Research, Review, 1994.

163 “High Level Skills and Industrial Competitiveness: Post-Graduate Engineers and Scientists in Britain and Germany”, Mason G and Wagner K, National Institute of Economic and Social Research, Report Series, Number 5, 1994.

164 "Britain's Productivity Performance 1950 – 1996", O'Mahony M, National Institute of Economic and Social Research, 1999. And "Britain's relative productivity performance: Updates to 1999: Final Report to DTI/Treasury/ONS", O'Mahony M and de Boer W, National Institute of Economic and Social Research, March 2002, http://www.niesr.ac.uk/research/BRPP02.pdf

165 "Innovation, Product Quality, Variety, and Trade Performance: An Empirical Analysis of Germany and the UK", Anderton R, Oxford Economic Papers, Volume 51, No: 1, pages 152 – 167, January 1999. This paper uses the framework of the new trade and endogenous growth models and theories.

166 "Skills, Performance and New Technologies in the British and German Automotive Component Industries", National Institute of Economic and Social Research, Mason G, Wagner K, July 2002. Despite improvements in recent years in British performance, the German automotive components industry has been and remains much larger than its British counterpart – in terms of output and employment – and still enjoys a lead in labour productivity. In production areas German advantages in physical capital intensity and production scale were reinforced by workforce skills, at least as proxied by formal qualifications. This applied at both technician pre-graduate level and at graduate level.

167 "Engineering Skills Formation in Britain: Cyclical and Structural Issues", Skills Task Force Research Paper 7, Mason G, National Institute of Economic and Social Research, September 1999, http://www.dfee.gov.uk/skillsforce/9.htm This paper also has further references by Mason and others, National Institute of Economic and Social Research, 1997 and 1996, dealing with work force skills, product quality and economic performance. See also for earlier research "Productivity, Education and Training: An International Perspective", Volumes I and II, edited by Prais S, Cambridge University Press, September 1995.

168 The data found in this section has been extracted from the outstanding publication "The World Economy: A Millennium Perspective", Maddison A, OECD, April 2002, http://www.oecd.org.uk This book covers the entire world economy over the past two thousand years. There is a vast array of data on life expectancy, infant mortality, population, exports, imports and output.

169 For those with a sound mathematical background, see "Economic Growth", Barro Robert J, Sala-i-Martin Xavier, First MIT Press edition 1999, for an excellent and rigorous exposition of contemporary growth theory including the recent endogenous growth models.

170 "Technical Change and the Aggregate Production Function", Solow R M, The Review of Economics and Statistics, volume 39, August 1957, pages 312 – 320. The fundamental differential equation of the Solow growth model is $dk/dt = s f(k) - (n + d)k$. See page 18 in reference 110, and Chapter One "Growth Models with Exogenous Savings Rates" for further details.

171 Growth in the long run required improvements in technology but as this process was outside the model he used, economic growth (and hence total factor productivity) was regarded as (largely) "exogenous". Another less than satisfactory aspect of the Solow (or Solow-Swan) model is that it implies "convergence" in growth rates, not generally observed in practice. In steady state, growth rates must be approximately the same and outside the steady state, low-income countries should grow faster. Neither is observed in practice, though there is some evidence of "convergence" with countries that are members of the Organisation of Economic Co-operation and Development (OECD). But the Solow-Swan model does tell us where to look: for factors that can cause steady state growth in technology. Also the model is more successful in explaining adjustment dynamics, where rough calculations show that adjustment to the steady state may take 20 to 30 years.

172 On this see "The Role of Education in Productivity Convergence: Does Higher Education Matter?", Wolff E, Gittleman M, In "Explaining Economic Growth, Szirmai A, van Ark B, Pilat D (editors), Amsterdam, North-Holland, 1993. The general view these days is that convergence is "conditional".

173 Page 562, "Ideas Gaps and Object Gaps in Economic Development", Romer P M, Journal of Monetary Economics, 1993, Volume 32 (3), pages 543 – 573.

174 For very recent empirical work on this see "Agglomeration Economies, Technology Spillovers and Company Productivity Growth", Geroski P, Small I, Walters C, Chapter 10, pages 236 – 267, In "Productivity, Innovation and Economic Performance", Barrel R, Mason G, O'Mahony M (editors), National Institute of Economic Research, Cambridge University Press, 2000. While the results suggest generally that company performance, particularly when measured by productivity growth or innovative output, is pretty erratic over time, nevertheless agglomeration effects were important in the industry sectors of Mechanical Engineering, Metals Manufacturing, Chemicals, Electrical Engineering, Textiles and Paper and Publishing. These are important innovation producing sectors with some being also regionally concentrated. So it is not, therefore surprising that external economies appear relatively more important in these sectors than elsewhere (see pages 239 – 246).

175 For this and more see “Post-Neoclassical Endogenous Growth Theory: What Are Its Policy Implications?”, Crafts N, Oxford Review of Economic Policy, Volume 12, No: 2, 1996. Also “Convergence or Divergence? The Impact of Technology on ‘Why Growth Rates Differ’ ”, Fagerberg J, Journal of Evolutionary Economics, 1995, Volume 5, No: 3, pages 269 – 284. And “Technology and Growth: An Overview”, and Discussion, Conference Series, Federal Reserve Bank of Boston, 1996, Volume 40, pages 127 – 150, and in this “Cross Country Variations in National Economic Growth Rates: the Role of ‘Technology’ “, De Long J B, Conference Series – Federal Reserve Bank of Boston, 1996, Volume 40, pages 1 – 32.

176 “A Structuralist View of Technical Change and Economic Growth”, Lipsey R G, Bekar C, Bell Canada Papers of Economic and Public Policy, 1995, Issue 3, pages 9 – 75. There is another related approach, the evolutionist perspective. On this see “Technology and Industrial Development in Japan: An Evolutionary Perspective”, Odagiri H, Journal of Economic Issues, Vol. XXXI, No: 2, June 1997. Analogies with Charles Darwin’s “Origin of Species” are frequently made although the author acknowledges that some observed facts do make “biological analogies difficult”. But these two approaches do stress the importance of path dependency. Path dependency results according to Odagiri from “the way scientific and technological knowledge grew (and the circumstances under which it grew) influences the level and composition of the capability of the firm, the industry, or the nation and, thereby, influences the speed and direction of future development”.

177 “A Structuralist View of Technical Change and Economic Growth”, Lipsey R G, Bekar C, Bell Canada Papers of Economic and Public Policy, 1995, Issue 3, pages 9 – 75.

178 Fuel cell technology and nanotechnology is included here. But some would add that a third “revolution” is also taking place in health and bioengineering.

179 There is evidence that this is now happening in the USA with respect to the ICT revolution. See “The Emerging Digital Economy II”, U.S. Department of Commerce, Washington DC, 1999, available from http://www.ecommerce.gov And in the UK too, “ICT and GDP Growth in the United Kingdom: A Sectoral Analysis”, London Economics, 2003. The report, undertaken for Cisco Systems, quantifies the contribution of Information and Communication Technologies (ICT) to output and productivity growth for twelve sectors of the UK, using growth accounting techniques. See http://www.londecon.co.uk/Publications/frmpublications.htm

180 “A Structuralist View of Technical Change and Economic Growth”, Lipsey R G, Bekar C, Bell Canada Papers of Economic and Public Policy, 1995, Issue 3, pages 9 – 75, page 16.

181 “The Value Added Scoreboard”, Department of Trade and Industry, May 2002, DTI/Pub6033/7K/02NP, http://www.dti.gov.uk

182 See reference 118, page 10. “The basic definition of VA for a company is sales less the cost of bought-in materials, components and services. The data needed to calculate VA in this way is rarely given in annual reports so an alternative approach is used: VALUE ADDED = OPERATING PROFIT+EMPLOYEE COSTS+DEPRECIATION AND AMORTISATION

183 “The Value Added Scoreboard”, Department of Trade and Industry, April 2003, DTI/Pub6601/4K/04/03NP, http://www.innovation.gov.uk/projects/value_added/highlights.html and http://www.innovation.gov.uk/projects/value_added/analysis.html

184 For very recent empirical work on this see “Agglomeration Economies, Technology Spillovers and Company Productivity Growth”, Geroski P, Small I, Walters C, Chapter 10, pages 236 – 267, In “Productivity, Innovation and Economic Performance", Barrel R, Mason G, O’Mahony M (editors), National Institute of Economic Research, Cambridge University Press, 2000. While the results suggest generally that company performance, particularly when measured by productivity growth or innovative output, is pretty erratic over time, nevertheless agglomeration effects were important in the industry sectors of Mechanical Engineering, Metals Manufacturing, Chemicals, Electrical Engineering, Textiles and Paper and Publishing. These are important innovation producing sectors with some being also regionally concentrated. So it is not, therefore surprising that external economies appear relatively more important in these sectors than elsewhere (see pages 239 – 246).

185 “The Importance of Physics in the UK Economy”, produced by the Institute of Physics, March 2003, http://industry.iop.org/PBI/PBIallin.pdf.

186 “Engineering and Physical Sciences in the UK”, Science and Technology Policy Research (SPRU), Gustavo Crespi and Pari Patel, University of Sussex at Brighton, funded by the Engineering and Physical Sciences Research Council, October 2003.

187 "Productivity and competitiveness indicators update 2002", Department of Trade and Industry 2002, see charts 2 & 3, page 7, http://vdti.gov.uk/competitiveness/indicators2002 The next set of productivity and competitiveness indicators were published in November 2003, although no significant changes occurred in the value of the indicators discussed here. However some new indicators were introduced. See "Productivity and competitiveness indicators 2003" department of Trade and Industry, November 2003, http://www.dti.gov.uk/competitiveness/indicators2003.htm

188 Estimates by O'Mahony and de Boer. See "Britain's relative productivity performance: Updates to 1999", O'Mahony M, de Boer W, National Institute for Economic and Social Research (NIESR), 2002.

189 "Britain's relative productivity performance: Updates to 1999", O'Mahony M, de Boer W, National Institute for Economic and Social Research (NIESR), 2002 http://www.niesr.ac.uk See also "UK Competitiveness: moving to the next stage", Porter M E, Ketels C H M, Department of Trade and Industry Economics Paper No: 3, May 2003, http://www.dti.gov.uk

190 "UK Competitiveness: moving to the next stage", Porter M E, Ketels C H M, Institute of Strategy and Competitiveness, Harvard Business School, DTI Economics Paper No: 3, DTI, May 2003, http://www.dti.gov.uk

191 The IMF presents a slightly different view in "United Kingdom: Selected Issues", IMF Staff Country Report 03/47, Washington, D.C., 2003, where it finds that total factor productivity differences are the main driver of the UK productivity gap versus all countries. However, the authors also acknowledge that total factor productivity is often connected to capital investment.

192 The neoclassical growth accounting mechanism used does not allow for the possibility that there may be external benefits from skill acquisition whereby the productivity of all workers is raised and is not captured any particular group of workers in the form of higher wage payments. This methodology has also been criticised for not allowing for the effects of complementarities among factor inputs and technological change. This is exactly the same point made in footnote 4, page 9 in "Productivity and competitiveness indicators update 2002", Department of Trade and Industry 2002 where it is stated that "This analysis, which uses growth accounting should be regarded as broadly indicative, as it does not tale account of the interdependencies and complementarities that exist between different factors of production", http://www.dti.gov.uk/competitiveness/indicators2002

193 See page 211, figure 1.2 in "SET for success: the supply of people with science, technology, engineering and mathematical skills", Report for the Chancellor of the Exchequer, April 2002. The whole report can be found on the web site: http://www.hm-treasury.gov.uk by going to the Research and Enterprise Index. Or direct to http://www.hm-treasury.gov.uk/documents /enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm

194 "Supply Side Policy and British Economic Decline", Crafts, N F R, in HM Treasury, "Economic Growth and Government Policy", 2001.

195 See Chart B.4, page 18, in "Productivity and competitiveness indicators update 2002", Department of Trade and Industry 2002, http://www.dti.gov.uk/competitiveness/indicators2002 The next set of productivity and competitiveness indicators were published in November 2003, although no significant changes occurred in the value of the indicators discussed here. However some new indicators were introduced. See "Productivity and competitiveness indicators 2003" Department of Trade and Industry, November 2003, http://www.dti.gov.uk/competitiveness/indicators2003.htm

196 See Chart B.5, page 19, in "Productivity and competitiveness indicators update 2002", Department of Trade and Industry, http://www.dti.gov.uk/competitiveness/indicators2002 The next set of productivity and competitiveness indicators were published in November 2003, although no significant changes occurred in the value of the indicators discussed here. However some new indicators were introduced. See "Productivity and competitiveness indicators 2003" department of Trade and Industry, November 2003, http://www.dti.gov.uk/competitiveness/indicators2003.htm

197 "UK Competitiveness: moving to the next stage", Porter M E, Ketels C H M, Institute of Strategy and Competitiveness, Harvard Business School, DTI Economics Paper No: 3, DTI, May 2003, http://www.dti.gov.uk

198 "Lambert Review of Business-University Collaboration, Final Report", published by H M Treasury, December 2003, see http://www.hm-treasury.gov.uk/media//EA556/lambert_review_final_450.pdf and http://www.hm-treasury.gov.uk/consultations_and_legislation/lambert/consult_lambert_index.cfm Interestingly the Lambert Review proposed some ideas to overcome the "disconnect" observed in the earlier Roberts review. Firstly it thought the market signals should be improved and that the best way to do this would be to require the universities to publish appropriate information in their prospectuses on graduate and postgraduate employability for each department or faculty. The information should include employability statistics ands first destination salary data. Employers' needs should be met by ensuring that the Sector Skills Councils (SSCs) have a real influence over university courses and curricula. Otherwise the government will fail to have an impact on addressing employers' needs for undergraduates and postgraduates. Employers are likely to give up on the process if they are not given real influence. But as the Roberts Review also found evidence that uncompetitive salaries were deterring many talented students from pursuing careers on science, engineering and technology, then employers of SET graduates may have to pay them more if they want to employ more graduates in future.

199 "Competing in the Global Economy: the innovation challenge", the Innovation Report, DTI, December 2003, see http://www.dti.gov.uk/innovationreport/index.htm or http://www.dti.gov.uk/innovationreport/innovation-report-full.pdf Innovation was defined here simply as "the successful exploitation of new ideas".

200 "Financing of High Technology Business: A report to the Paymaster General", HM Treasury, November 1998 and "Harvesting Technology: Financing technology-based SMEs in the UK", Pickering G, Centre for the Study of Financial Innovation, April 2002.

201 "OECD Economic Outlook", Volume 2003/1, No: 73, June 2003, page 147, Figure V.6.

202 See Charts E.1 and E.2, page 32, in "Productivity and competitiveness indicators update 2002", Department of Trade and Industry 2002, http://www.dti.gov.uk/competitiveness/indicators2002 The next set of productivity and competitiveness indicators were published in November 2003, although no significant changes occurred in the value of the indicators discussed here. However some new indicators were introduced. See "Productivity and competitiveness indicators 2003" department of Trade and Industry, November 2003, http://www.dti.gov.uk/competitiveness/indicators2003.htm

203 "Openness and Growth", Proudman J, Redding S, 1998

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205 "Wealth Creation from Science, Engineering and Technology", a report to the Engineering and Technology Board by London Economics, published March 2004, http://www.scenta.co.uk/uploads/ETB_London_Economics.pdf

206 "ICT and GDP Growth in the United Kingdom: A Sectoral Analysis", London Economics, 2003. The report, undertaken for Cisco Systems, quantifies the contribution of Information and Communication Technologies (ICT) to output and productivity growth for twelve sectors of the UK, using growth accounting techniques. See http://www.londecon.co.uk/Publications/frmpublications.htm

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1. **Adult Learning Inspectorate**
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CV5 6UB
Tel: 0870 240 7744
www.ali.gov.uk

2. **Assessment and Qualifications Alliance**
Simon Eason
Research and Statistics Group
Stag Hill House, Guildford
Surrey GU2 5XJ
Tel: 01483 506 506
www.aqa.org.uk

3. **Association of Graduate Recruiters**
Sheraton House, Castle Park
Cambridge CB3 0AX
Tel: 01926 623 236
www.agr.org.uk

4. **Centre for Economic Performance**
London School of Economics and
Political Science
Houghton Street
London WC2A 2AE
Tel: 020 7955 7284
www.cep.lse.ac.uk

5. **Collective Enterprises Limited**
Bleaklow House
Howard Town Mills
Glossop SK13 8HT
Tel: 01457 868003
www.cel.co.uk

6. **Construction Industry Training Board (CITB)**
www.citb,org.uk

7. **CSU Limited**
Prospects House
Booth Street Esat
Manchester M13 9EP
Tel: 0161 277 5200

8. **Department of Trade and Industry**
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Tel: 020 7215 5000
www.dti.gov.ukb

9. **Department for Education and Skills**
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www.dfes.gov.uk

10. **DfES Publications**
0845 602 260

11. **EDEXCEL Foundation**
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Tel: 020 7393 4444
www.edexcel.org.uk

12. **Employment Research Institute**
Napier University
66 Spylaw Road
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EH18 5BR
Tel: 0131 455 5104
www.napier.ac.uk

13. **Engineering Employers' Federation**
Broadway House, Tothill Street
London SW1H 9NQ
Tel: 020 7222 7777
www.eef.org.uk

14. **European Commission**
Representation in the UK
8 Storey's Gate
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Tel: 020 7973 1992
www.cec.org.uk

15. **European Federation of National**
Engineering Associations (FEANI)
Rue du Beau Site 21, 1050 Brussels
Belgium
Tel: 00 32 2 639 0390
www.feani.org

16. **Graduate Teacher Training Register**
www.gttr.ac.uk

16. **Her Majesty's Treasury**
www.hm-treasury.gov.uk

17. **Higher Education Funding Council**
for England
Northavon House, Coldharbour Lane
Bristol BS16 1QD
Tel: 0117 931 7317
www.hefc.ac.uk

18. **Higher Education Statistics Agency**
18 Royal Crescent, Cheltenham
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www.hesa.ac.uk

19. **Institute of Directors**
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21. **Institute for Employment Studies**
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23. **Institute of Employment Studies**
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www.employment-studies.co.uk

24. **Joint Council for General Qualifications**
www.jcgq.co.uk

25. **Learning and Skills Council**
www.lsc.gov.uk

26. **London Economics**
60 Lombard Street
London EC3V 9EA
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27. **National Institute of Economic and Social Research**
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www.niesr.ac.uk

28. **National Science Foundation**
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Arlington
Virginia 22230, USA
Tel: 00 1 703 306 12
www.nsf.gov/sbe/srs/seind02/pdfstart.htm .

29. **nCRISP**
The Construction Industry Research and Innovation Strategy Panel
www.crisp-uk.org.uk

30. **Office for National Statistics (ONS)**
1 Drummond Gate
London SW1V 2QQ
Tel: 020 7233 9233
www.nationalstatistics.gov.uk

31. **Office for Standards in Education (ofsted)**
Alexandra House
33 Kingsway
London WC2B 6SF
www.ofsted.gov.uk

32. **Office of Science and Technology (OST)**
Department of Trade and Industry
1 Victoria Street
London
SW1H 0ET
Tel: 020 7215 5000
www.ost.gov.uk

33. **Office of Science and Technology**
Promoting SET for Women Unit
www2.set4women.gov.uk/set4
women/statistics/index.htm

34. **Qualifications and Curriculum Authority**
29 Bolton Street
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Tel: 020 7509 555
www.qca.org.uk

35. **The Royal Academy of Engineering**
29 Great Peter Street
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36. **The Scottish Qualifications Athority**
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http://80.75.66.188/sqa/sqa
_mainHomepage.jsp?p_service
=Content.show&pContentID
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37. **Science, Engineering and Manufacturing Technologies Alliance**
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38. **Universities and Colleges**
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