# 10 STEM Supply and Demand Research

# STEM Literature Review

## 1. INTRODUCTION

The supply and demand issues relating to graduates in Science, Technology, Engineering and Mathematics (STEM) disciplines have been a matter of concern since numbers began to drop in the 1990s. Uptake of the physical sciences, chemistry and mathematics has proved to be of especial concern. These supply and demand issues have resulted in a raft of policy initiatives and strategies by Government and other interested parties to reverse the decline.

This review will briefly examine the policy context and uptake issues relating to STEM subjects in secondary schools feeding through into HE. The review will then focus on the societal and other factors influencing secondary school pupils' and graduates' subject choices. The under–representation of girls and people from BME (Black and Minority Ethnic) groups will also be examined. The current investigation concurred with a CaSE study, finding information relating to the participation of those with disabilities in STEM subjects to be only piecemeal (2008). An overview of some current strategies relating to the promotion of STEM subjects will also be covered.

## 1.1 Policy Context

Increasing the uptake of STEM subjects by young people is a key policy focus in the UK. This goal is supported by a range of policies and strategies that are needed to meet the complex challenges related to attracting more young people to study STEM subjects. The demand for graduates qualified in these disciplines is high, both in industry and academia, not only in areas with scientific or engineering specialisms, but also in sectors such as financial services.

At the start of the decade, the Government commissioned reviews to investigate the challenge of how the supply of young people qualified in STEM subjects can meet the labour market demands for these skills. *A review by Sir Gareth Roberts, SET for success: The supply of people with science, technology, engineering and mathematics skills* (2002) outlined the following issues relating to the supply of scientists and engineers (pp 2–3):

- A downward trend in the numbers studying mathematics, engineering and physical sciences, masked by growth in the number of students for IT and the biological sciences, resulting in skills shortages
- A shortage of women choosing to study STEM subjects at A level and in higher education
- Poor experiences of science and engineering education, coupled with a negative image of or inadequate information about the careers available to science and engineering graduates
- A lack of attractive career opportunities in research, given other sectors' requirements for STEM skills
- Shortages in the supply of physical science and mathematics teachers/lecturers
- Poor environments in which science, design and technology practicals are taught
- These subjects' ability to inspire and interest pupils, especially girls
- Careers advice and the way it affects pupils' desire to study STEM subjects at higher levels
- Issues with transition from studying at A–level to degree level in these subjects

Professor *Adam Smith's Inquiry into Post–14 Mathematics Education (Making Mathematics Count, 2004)* similarly found a drop in the numbers taking A–level mathematics in England was influenced by a combination of factors including the supply of appropriately qualified mathematics teachers in secondary schools; young people's perceptions of the subject (as 'boring' or 'difficult'); lack of resources and sustained CPD for teachers of mathematics; failure of the curriculum to interest and motivate, and lack of awareness of the importance of mathematical skills for future career options.

SETFair, the focus on girls and women, followed the Roberts Review, the report on regionalisation of STEM support by Sir Gareth Roberts in 2005. Out of this came the UK Resource Centre for Women in SET funded by the then DTI.

To address these challenges, the Government has launched a series of policy initiatives, including a 10 year Framework for Science and Innovation (the *Science & Innovation Investment Framework 2004 – 2014; Science and Innovation Investment Framework: next steps*, 2006), which made investment a priority; made a commitment to improve attainment in science at KS3 and GCSE; increase the number of young people taking A levels in physics, chemistry and mathematics; and step up recruitment, retraining and retention of physics, chemistry and mathematics teachers.

DCSF's STEM *Programme Report* also outlines the Government's commitment to attract and retain teachers of STEM subjects, provide them with the right continuing professional development (CPD); get the STEM curriculum right and provide the right activities and careers advice so that STEM is given a real world context within the classroom. This is where Action Programme 8 (of a total of 11 Action Programmes) STEM Subject Choice and Careers, lies.

DIUS's *Innovation Nation* (2008) white paper builds on the 2004 *Science & Investment Framework* and Lord Sainsbury's Review (*The Race to the Top: A Review of Government's Science and Innovation Policies* (2007)) to promote innovation across the UK's society and economy, including proposals about how the Government can use procurement and regulation to promote innovation in business and facilitate the interchange of innovation expertise between the public and private sectors. *A Vision for Science and Society* (2008) reiterates the Government's priority to increase the number of people who choose to study scientific subjects and work in research and scientific careers; and also aims to strengthen the level of high quality engagement with the public on all major science issues.

## 2. SUPPLY AND DEMAND FOR STEM SUBJECTS

In this section we look at both the stock (those qualified in STEM and available to the labour market) and flows into STEM courses and careers.

According to the DfES (2006a) report on supply and demand of STEM in the UK economy, the stock of STEM graduates compares well internationally. Between 1997 and 2004 there has been an increase in the proportion of doctorates in STEM subjects in the working age population of 40% compared to an increase in non-STEM subjects of 37% (DfES, 2006a).

### 2.1 Supply

HEFCE figures show that while graduate numbers are increasing for all levels of qualification over the period 2002-03 to 2005-06, there has been little or no increase in the number of people graduating from programmes involving strategically important and vulnerable subjects, such as modern foreign languages or selected science disciplines, between 2002-03 and 2005-06 (HEFCE, 2008).

In the same timeframe, the DfES (2006a) reports that there has been an increase of 57% in the estimated number of STEM graduates to 2.1 million in the working age population. This increase, will of course, be correlated with the rise in graduates overall as part of the Government strategy. Most interesting, DfES (2006a) shows a higher growth rate for STEM subjects compared to non-STEM.

Engineers continue to be the largest stock of STEM graduates in the population but with recent increases in the numbers of those holding biological sciences; medicine and allied (e.g. nursing and pharmaceutical); and mathematics and computer sciences.

Increases in the stock include:

Biological sciences: newer subjects like microbiology showing higher growth than older subjects like biology. Those studying psychology (including those who study it as a social science) are now included in biological sciences. The 110% growth in biological sciences between 1997 and 2004 can therefore be partly attributable to this re-classification. However, biological sciences would still have increased by 64% without the additional psychologists (DfES, 2006a).

The increase in mathematical sciences and computing is largely due to the increase in computing graduates (144%) rather than those in mathematics and computing. (DfES, 2006a).

It comes as no surprise that between 1997 and 2004, Chemistry and Physics graduate numbers grew at a slower rate: Chemistry – 24%; and Physics – 20% respectively. Growth in physical/environmental sciences graduates was 41% (DfES, 2006a).

While the stock of engineering graduates in the workforce is relatively high, there is mixed growth in engineering disciplines. Production & manufacturing systems engineering graduate numbers grew by 45% and civil engineering numbers by 44%.

Meanwhile, general and chemical engineering numbers grew 13% and mechanical engineering numbers just 5% (Science, Engineering and Technology Skills in the UK, DTI March 2006 cited in DfES 2006a).

The definition of STEM varies in the literature, therein showing the complexity of 'measuring' supply and demand in the field. In this section we will highlight any differences in the text.

As stated above and stated in DfES (2006a):

> 'there is also a need to take into consideration the expansion of HE during this period and examine STEM subjects as a proportion of all subjects taken for first degree. Analysis on the absolute numbers of first degree entrants to STEM subjects shows Engineering & Technology and Physical Science entrants (including Chemistry and Physics) has fallen. Chemistry entrants have also fallen, whereas entrants to Physics appear to be relatively constant over the period. The most recent data for Computer Sciences also shows sharp fall but it is too early to tell if this is a trend. Subjects allied to Medicine have had quite large increases in entrants over the period. All other STEM subjects have stayed relatively constant over the period 1994/95 to 2004/05.'

Analysing graduates provides only a snapshot. To look at future supply, we must analyse the flows into STEM from the educational system leading to degrees. At the very basis of the calculations, the DIUS cites a recent report by Universities UK (UUK 2008, *The future size and shape of the higher education sector in the UK: demographic projections*, UUK Research Report) which estimates that enrolments among full-time undergraduates will not increase significantly between now and 2027, due to the demographics of the 18–20 year old population and that in the period between 2009 and 2020, there will be a very significant downturn in the relevant young populations throughout the UK. Thus, according to the DIUS work (2009), although there will be increases in part-time undergraduates, STEM will be hard hit *if* most courses continue to be full-time, as most STEM undergraduates study full-time.

Returning to our snapshot, the proportion undertaking STEM qualifications in Foundation Degrees has remained constant but the proportion is lower than that in HND/HNC and first degree qualifications (DfES, 2006a).

STEM first degree entrants in Physical Sciences (Chemistry and Physics included), Engineering & Technology and Architecture, Building and Planning have all fallen as a proportion of all entrants. In addition, there has also been a decline in Computer Studies.

According to DfES (2006a), flow into mathematics has declined in absolute numbers but in more recent years numbers have stayed relatively constant. Physics has shown a decline over the years 1996 to 2005, with Computer Studies also in decline in the last few years. Design & Technology has increased over the period as well as ICT in more recent years; from 1999 onwards. All other STEM subjects shown have stayed relatively constant.

The STEM A-level subjects as a proportion of all subjects show considerable decreases for Mathematics, Chemistry, Physics, with Biological Sciences also in decline between 1996–2005. In more recent years computer studies has also decreased but Chemistry has remained relatively stable. All other subjects have stayed relatively constant, apart from Design & Technology which is the only subject to have increased its share (DfES, 2006a).

In terms of destination after A level, unsurprisingly, trends in the numbers of those with A levels in STEM have effects upon those who enter HE to study STEM (DfES, 2006a; DIUS, 2009). For those who have two or more STEM A levels, 73% of the 2003 Youth Cohort Study (10th Cohort study) go on to take first degrees in STEM (71% if psychology is excluded),

**Area of Study at A Level and First Degree**

| STEM A-levels | Proportion of first degree participants taking STEM | |
|---|---|---|
| | Cohort 10 (2003) | Cohort 11 (2005) |
| **Two or more** | 73% (71%)' | 73% (75%)' |
| **One** | 56% (54%)' | 51% (53%)' |

Source: Youth Cohort Study 10 (2003) and 11 (2005) from DfES (2006a)

Please note: Here STEM does not include sports science. A level attained by academic age 18 and HE subject of study is measured at 19; this includes those who took a gap year after A levels but not those who drop-out prior to 19.

The DIUS shows how higher GCSE attainment tends to be associated with more A Level passes in Science subjects. However, if one holds the number of science A Level passes constant, the study finds very little difference in GCSE attainment between those who do STEM in HE and those who don't (DIUS, 2009).

The DIUS goes on to discuss how the greatest "leakage" from STEM from the education system is the proportion of young people who do not go on to attain any A Level qualifications at all: the vast majority of the DIUS selected cohort (or two thirds) do not attain any A Levels at all at a pass A–E (although some of them may still obtain other Level 3 qualifications, including vocational ones). However, 95% of these young people will not be in HE at the age of 19. The second greatest "leakage" from STEM are the 71% who achieve at least one A Level pass, but not in a science subject. 10% (or around 53,800) of the cohort attain at least one A Level pass in a science subject. This includes: around 26,400 young people with one science A Level pass; 17,800 with two science A Level passes; 8,900 with three science A Level passes; and 700 with four science A Level passes. Not all young people with science A Levels will go on to study STEM in HE, and some people with no science A Levels will end up studying STEM.

As stated above, the likelihood of studying STEM in HE increases with the number of science A Level passes the individual has. The data used by the DIUS shows that 11% of those with no science A Level passes will do STEM in HE, compared to: 36% of those with one science A Level pass; 69% of those with two science A Level passes; 84% of those with three science A Level passes; 91% of those with four science A Level passes. (DIUS, 2009)

In terms of supply we see that a large proportion of science graduates do not work in science occupations. Only around half of STEM graduates work in science occupations three and half years after qualifying. Even after factoring in STEM graduates who work in finance (around 4–8%) and in teaching (around 9%), this still leaves a significant proportion of STEM graduates working in non–STEM related occupations of around 34%–38%.

CaSE (2008) refers to STEM supply as a pipeline; with problems with supply due to low input into the pipeline (supply of STEM qualified workers in the early stages) and 'leaks' in the pipeline (workers leaving STEM careers in later stages). With regard to gender in the input stages, Appendix 1 provides a breakdown of 2007 enrolment to STEM undergraduate courses (including IT) by gender (UCAS, 2008 www.ukrc4setwomen.org accessed 30 March 2008).

**Enrolment to STEM Undergraduate Courses at UK HE Institutions by Gender, 2007**

| Subjects to be studied for HE qualifications | Female | Male | Total | Female (%) | Male (%) |
|---|---|---|---|---|---|
| All Subjects | 45,561 | 83,317 | 128,878 | 35.4% | 64.6% |

(UCAS, 2008 from www.ukrc4setwomen.org accessed 30 March 2008)

The analysis of the 2007 data undertaken by UKRC shows that male enrolment is significantly higher over all STEM subjects compared to female (65% and 35% respectively). There are variations by subject area, however, with the proportion of females higher than males on courses related to medicine; biological sciences; zoology; forensic and archaeological science.

The 'leaks' in the pipeline may be caused more by women leaving STEM careers. While women 'returners' – referring to women who take a break from career for caring, usually for children, form a quarter of the labour force in the UK (WWC, 2006), women may face greater barriers to returning to STEM careers than others. Women may leave the STEM workforce when they take a break for childcare, the latter still predominantly taken up by mothers rather than fathers. Career breaks, and child and other caring responsibilities have an impact on returns to STEM careers. Women returners in general find that there are various issues confronting them: After an extended period away from work, women may face many barriers to returning including low confidence, knowledge of the current labour market and outdated skills. For women who have only taken a short break it can be difficult to return to or find jobs that match their skills, if they need to work more locally or part time, due to childcare and school arrangements, transport and distance to travel to work as considerations (WWC, 2006).

STEM qualified women returners may find that teaching, for example, provides a more flexible working pattern and potential to work more locally than their previous careers. According to the WWC report, women returners tend to under–utilise their past training, particularly scientific and technical training (2006). Specific examples are many. The British Medical Association, for example, told the Commission of negative attitudes to flexible working within the medical profession – a STEM career area attracting many women, which currently views flexible and part–time workers as being less committed (WWC, 2006).

Conversely, one factor that has an impact on the supply of STEM students and graduates is the supply of qualified teachers in science and mathematics. Teacher qualifications in physics and pupil performance are correlated (Smithers and Robinson,2005), while the stock of physics teachers qualified in physics is diminishing (39% of leavers in 2004 had physics as their main subject, compared with 32.8% of newly appointed teachers). Nearly a quarter of 11–16 schools (23.5%) have no teacher at all who has studied physics to any level at university. There is also a 'retirement time bomb' faced by schools with 31.1% of physics teachers aged 51 and over, while only 16.6% are aged 30 and under.

An analysis of those eligible (i.e. those with a degree–level qualification related to maths and science) to teach mathematics and science in secondary schools in the UK (TDA, 2008), shows that the average age of non–teachers eligible to teach as around 38. 61% of non–teachers with eligible degrees are male, 21% higher than the proportion of males with eligible degrees who have enquired about teaching on the Teaching Information Line (TIL). Graduates from BME backgrounds are more likely to have eligible degrees, but are less likely to become teachers compared with people from white backgrounds. Individuals eligible to teach maths and science earn on average £6,200 per year less as teachers than in other areas of employment, which is likely to have an impact on the recruitment of STEM graduates to the profession.

## 2.2 Demand

The DIUS study on demand for STEM skills used data from the Labour Force Survey (LFS) 2008 for the UK working age population to ascertain employment rates for STEM graduates compared to non–STEM graduates as a proxy for demand. The rationale goes that if STEM employment rates are higher than those for the non–STEM, then this suggests that the skills for the former are in relatively high demand. The evidence reveals that employment rates for graduates overall are very high, with relatively little difference between the employment rates of STEM graduates (89%) and non–STEM graduates (87%) (DIUS, 2009).

According to the DfES (2006a) report, Maths, Natural Science and Engineering graduates have a higher chance of being unemployed for 6 months or longer following graduation compared to Medicine (base case), controlling variables such as age, social class, degree class and type of institution. These three subject areas were all fairly even compared to each other and also with most other non–STEM subject areas, apart from Arts graduates, where there was a much higher chance of being unemployed for 6 months or more.

The Working Futures projections suggest an increase in the demand between now and 2014 for science and technology professionals and science and technology associate professionals of 18% and 30% respectively, compared to an increase for all other occupations of 4% (DfES, 2006a).

The HEFCE (2008) report provides an analysis of destinations of STEM and other graduates. If we use employment in a graduate–level position as a proxy for demand, we can see that Chemistry, Medicine and Health–related are all in high demand measured by the proportion employed 3.5 years after graduation from their first degree (HEFCE, 2008).

**Proportion of Graduates Employed 3.5 Years after Graduation from First Degree**

| Subject | Graduate occupation |
|---|---|
| **Medicine** | **98%** |
| **Nursing** | **97%** |
| **Pharmacy and pharmacology** | **95%** |
| Architecture, building and planning | 92% |
| **Chemistry** | **91%** |
| Health studies | 91% |
| **Anatomy and physiology** | 89% |
| Education | 89% |
| **Physics, astronomy** | **85%** |
| **Biosciences** | **82%** |
| Sports science | 82% |
| Geography | 82% |
| **Engineering** | **81%** |
| **Mathematical sciences** | **80%** |
| Modern foreign languages | 80% |
| **Other physical sciences** | **79%** |
| ITS and computer software engineering | 77% |
| Humanities and language–based studies | 77% |
| Design and creative arts | 74% |
| Sociology, social policy and anthropology | 73% |
| Combined | 72% |
| **Psychology** | **71%** |
| Business and management | 68% |
| **Land-based studies** | **62%** |
| Media studies | 60% |
| Finance and accounting | 58% |
| **Mean** | **79%** |

*Source: HEFCE (2008: 23)*

Another measure of demand is hard–to–fill vacancies or recruitment difficulties, typically measured by surveying employers.

A recent survey of 735 businesses (7.6% response rate) by the CBI (*Education and Skills Survey 2008)* cited in DIUS (2009), found that 59% of businesses employing people with STEM skills are experiencing difficulties recruiting. One–third reported issues recruiting experienced individuals and almost one–quarter (23%) stated they had problems recruiting graduates.

The DIUS report also cites the list of shortage STEM occupations drawn up by the Migration Advisory Committee, a list that combines labour market shortage occupations that are above Level 3 and that it would be sensible to fill the gaps with migrant labour. The list, drawn up in 2008 is:

- Medical practitioners and Dental practitioners
- Nurses
- Health professionals, Health associate professionals and Health care scientists
- Civil engineers
- Chemical engineers
- Aircraft component manufacturing engineers
- Electricity transmission overhead lines workers
- High Integrity Pipe Welders
- Physicists, geologists and meteorologists
- Quantity Surveyors
- Project managers for property development and construction
- Veterinary Surgeons

DIUS (2009:9)

Sources of recruitment for shortage areas can include migrant labour. Ethical issues are relevant particularly when recruitment is from less developed economies than UK.

## 2.3 Rates of Return to Studying STEM

A key component of encouraging young people into STEM subjects, particularly when they take on debt to study, will be the returns to their studies in the form of earnings; employment rates; and types of careers available. The rates of return and employment rates will be particularly important in times of economic downturn.

Both the DfES (2006a) and the DIUS (2009) have produced data on the rates of return to STEM.

The DIUS analysis indicates that, overall, graduates have high employment rates, with relatively little difference between the employment rates of STEM graduates and non–STEM graduates (2009).

In terms of financial returns, overall, STEM graduates tend to have higher earnings than non–STEM graduates (DIUS, 2009). Wage returns to Medicine, Physical Sciences, Mathematics, Computing, and Engineering are higher than average, whereas Biology, other Biological Sciences (like Psychology) and Nursing tend to have lower than average salaries.

The DIUS findings suggest that there is a caveat – STEM graduates still earn more than non–STEM graduates – but only if they work in STEM or finance, once the data is controlled for other factors associated with earnings differences between graduates (e.g. age, gender, prior attainment etc.). This indicates that any positive earnings differential derived from studying STEM is lost if a STEM career is not followed, an important distinction for informed choice.

These income findings are situated within the context of an overarching gender pay gap which the Women and Work Commission report (2006) states cannot be explained purely by women's higher prevalence for part–time working and breaks from the labour market to take up caring responsibilities. Indeed, a gap between men and women's income is evident only a few years into working life. The gap is initially explained by the difference in occupational areas taken up by women and men (WWC, 2006).

According to HEFCE, of the strategically important subjects, engineering had the highest mean salary for employed graduates after six months (2008).

The older DfES study provides estimated gross weekly earnings for STEM graduates in three types of occupations: STEM jobs; teaching; and other occupations. The earnings are similar for all three groups, with teaching being the lowest both in 2001 and 2004. The wages of those in STEM occupations have increased the most, suggesting that the incentive (differential) for STEM graduates to go into STEM occupations is increasing. Looking at the same figures for non–STEM graduates shows that the latter earn a lot less in STEM occupations than STEM graduates, as you would expect, and also less in teaching (2006a).

So, the DfES and the DIUS studies (2006a and 2009) suggest that if you are a STEM graduate you can expect a higher rate of return to your study if you progress to a STEM or a finance–related career. A STEM graduate will not reap the differential rate of return if they progress to a non–STEM career. If you are a non–STEM graduate, you will earn a lower rate of return to your studies than a STEM graduate *even if you progress into a STEM related career.*

The DfES report also states that earnings for STEM graduates are increasing over time. The variation of annual average earnings of graduates, four years after graduation, by subject area shows that Mathematics & Computing and Medicine & related subjects have two of the highest average annual earnings for both men and women. Law was the only subject that was greater and only applied to men. The DfES report agrees with the DIUS findings, showing that Natural Sciences have relatively low average earnings, especially for women, and are comparable with subjects like Social Sciences and Languages. The other STEM subject area, Engineering, is also fairly comparable with the other subjects (both STEM and non-STEM), although women appear to earn less, on average, in this subject area (DfES, 2006a).

HEFCE (2008) provides a detailed analysis of self-declared salaries across a range of disciplines for those who graduated from full-time first degrees. The results of the data from 3.5 years after graduation are shown in the table below.

The analysis of destinations and salaries after the first degree does produce some anomalies. For example, a nursing degree combines the first degree with the clinical qualification. Other health-related qualifications qualify for clinical status while working. For other occupations, such as psychology, a first degree is only a springboard into further clinical qualifications. A clinical psychologist must study for a D.Clin. Psychology, entry onto which is highly competitive and to which several years of work experience is necessary before successful entry, but returns are greater than those shown for the first degree.

**Mean Salary of Graduates 3.5 Years after Graduation**

| Subject | Mean salary |
|---|---|
| **Medicine** | **£40,078** |
| **Pharmacy and pharmacology** | **£28,683** |
| Architecture, building and planning | £26,873 |
| Modern foreign languages | £26,823 |
| **Engineering** | **£26,006** |
| **Mathematical sciences** | **£25,757** |
| ITS and computer software engineering | £25,631 |
| **Physics, astronomy** | **£24,759** |
| Finance and accounting | £24,673 |
| Health studies | £24,357 |
| Humanities and language-based studies | £23,979 |
| **Nursing** | **£23,749** |
| Business and management | £23,552 |
| Sports science | £23,220 |
| **Other physical sciences** | £23,055 |
| Sociology, social policy and anthropology | £23,050 |
| **Anatomy and physiology** | **£22,973** |
| Education | £22,963 |
| Combined | £22,912 |
| Geography | £22,667 |
| **Chemistry** | **£22,512** |
| Design and creative arts | £21,788 |
| **Land-based studies** | **£21,615** |
| **Psychology** | **£21,391** |
| **Biosciences** | **£21,382** |
| Media studies | £21,187 |

*Source: HEFCE (2008: 28)*

# STEM Choices - A Resource Pack for Careers Education and Information, Advice and Guidance Practitioners

## Bibliography


Bagilhole B, Powell A, Barnard S, Dainty A (2008), *Researching Cultures in Science, Engineering and Technology: An analysis of current and past literature,* Loughborough University and UKRC

Barmby P and Defty N, *Secondary School pupils' perceptions of physics,* Research in Science and Technological Education, Vol 24, No 2, November 2006, pp. 199–215

CaSE (2008) 'Delivering Diversity: Making Science & Engineering Accessible to All' CaSE Policy Document Number 8, May.

Centre for Education and Industry/University of Warwick 2007 *Careers from Science* June, Science Education Forum

Cooper P and D'Inverno R (2005) *The future of the discipline? Mathematics and the Undergraduate Ambassadors Scheme,* Journal of Mathematics Teacher Education 2005 8:329–342

DCSF (2006) *STEM Programme Report*

DCSF (2008) *After–school Science and Engineering Clubs Evaluation*

DCSF (2008a) *Minority Ethnic Pupils in the Longitudinal Study of Young People in England: Extension Report on Performance in Public Examinations at Age 16*

DCSF (2008b) *STEM Careers Awareness Stakeholder Guide*

Demie, F (2001) *Ethnic and gender differences in educational achievement and implications for school improvement strategies,* Educational Research Vol. 43 No.1 Spring 2001 pp. 91–106

DfES, 2003 *Choice at the end of compulsory schooling: A research review*

DfES, 2004, *The influence of the School in the Decision to Participate in Learning Post–16*

DfES, 2006, *How Do Young People Make Choices at 14 and 16?*

DfES (2006a) *The Supply and Demand for Science, Technology, Engineering and Mathematics Skills in the UK Economy Research Report RR775*

DIUS (2008) *Innovation Nation*

DIUS (2008a) *A Vision for Science and Society*

DIUS (2008b) *Public Attitudes to Science Survey*

DIUS (2009) *The Demand for Science, Technology, Engineering and Mathematics (STEM) Skills* January

EEA, *Attracting more Entrants into the World of Engineering*

Elias, P, Jones, P, McWhinnie, S (2006), *Representation of Ethnic Groups in Chemistry and Physics,* The Royal Society of Chemistry and the Institute of Physics

EPPI, 2005, *Review: The effects of context–based and Science–Technology–Society (STS) approaches in the teaching of secondary science on boys and girls, and on lower–ability pupils*

EPPI (2006), *ICT in science teaching: The effect of ICT teaching activities in science lessons on students' understanding of science ideas*

EPPI (2006a), *Mathematics education: A systematic review of strategies to raise pupils' motivational effort in Key Stage 4 Mathematics*

Greenfield, S, Peters J, Lane, N, Rees, T, Samuels G (2002), *SET Fair: A report on Women in Science, Engineering and Technology*

Hargreaves M, Homer M and Swinnerton B, (2008) *A comparison of performance and attitudes in mathematics amongst the 'gifted'. Are boys better at mathematics or do they just think they are?* Assessment in Education: Principles, Policy and Practice, Vol 15, No 1, March 2008, 19 – 38

HEFCE (2008) *Graduates and their Early Careers* October 2008/39

HM Treasury (2004), *Science & Innovation Investment Framework 2004 – 2014;*

HM Treasury (2006), *Science and Innovation Investment Framework: next steps,*

IOP (2007), *Repackaging Physics Qualitative Research Debrief,* Hall & Partners Europe

Jenkins, E (2006), *Student opinion in England about science and technology,* Research in Science and Technological Education Vo. 24, No. 1, May 2006, pp. 59–68

Mendick H, Moreau M, Hollingworth S (2008), *Mathematical Images and Gender Identities: A report on the gendering of representations of mathematics and mathematicians in popular culture and their influences on learners*, Institute for Policy Studies in Education, LMU and UKRC

Morton P and Collins, J, *STEM Careers for Girls – A Position Paper by the UK Resource Centre for Women in STEM*, Centre for Science Education, Sheffield Hallam University

Murphy P, Whitelegg E (2006) *Girls in the Physics Classroom: A Review of the Research on the Participation of Girls in Physics*, Institute of Physics and Open University

National Science Learning Centre (2007) *Annual National Survey of Year 9 Students' Attitudes to Science*

NICEC (2000), *Choosing Science at 16: The Influences of Science Teachers and Careers Advisers on Students' Decisions about Science Subjects and Science and Technology Careers*

People Science & Policy (2008), *Engineering a Better World*

Roberts, G (2002) SET for success: *The supply of people with science, technology, engineering and mathematics skills*

Royal Academy of Engineering, *National Engineering Programme Leaflet*

Sainsbury, (2007) The Race to the Top: *A Review of Government's Science and Innovation Policies*

Science & Technology Facilities Council (2008) *Support for Teachers in Secondary Schools and Colleges*

Science Council (2005) *Careers from Science: final report and design proposal*, Sage Associates

Smart, S and Rahman, J (2008) *Bangladeshi Girls Choosing Science, Technology, Engineering and Maths*, Aimhigher and CfBT Education Trust

Smith, A (2004) *Inquiry into Post–14 Mathematics Education (Making Mathematics Count*

Smith, Hugh (2007) *A Review of the STEM Skills Supply Chain*, March, Council for Industry and Higher Education

Smithers, A and Robinson, P (2005) *Physics in Schools and Colleges: Teacher Deployment and Student Outcomes*, Centre for Education and Employment Research, University of Buckingham and The Gatsby Charitable Foundation

Springate, I, Harland J, Lord P and Wilkin A, (2008) *Why choose physics and chemistry? The influences on physics and chemistry subject choices of BME students*, The Institute of Physics and the Royal Society of Chemistry

Sturman, L, G. Ruddock, B Burge, B. Styles, Y. Lin, H. Vappula (2008) England's Achievement in TIMSS 2007 DCSF Research Brief

TDA (2008) *Review of data relating to those eligible to teach Mathematics or Science*, London Economics

UK Resource Centre for Women in Science, Engineering and Technology, *Career Pack Bibliography*

UUK (2008) *The Future Size and Shape of the Higher Education Sector in the UK: demographic projections*, UUK Research Report

Warrington, M and Younger M, (2003), *'We decided to give it a Twirl': single–sex teaching in English comprehensive schools*, Gender and Education, Vol 15, No 4, December 2003 pp. 339 – 350

Whitelegg, E, Holliman, R, Carr J, Scanlon E, Hodgson B, (2008) *(In)visible Witnesses: Investigating Gendered Representations of Scientists, Techologists, Engineers and Mathematicians on UK Children's Television*, UK Resource Centre for Women in Science, Engineering and Technology (UKRC) and Open University

WISE (2004) *In a class of their own? Teaching science in single sex classes in secondary co–educational schools: Guide to Good Practice*

WISE (2005) *SET for a great future: How to inspire girls – and boys – about SET careers in the engineering and construction industries*

Women and Work Commission (2006) *Shaping a Fairer Future*

## Appendix 1: Enrolment to STEM Undergraduate Courses: UK HE Institutions by Gender, 2007

| Subjects to be studied for HE qualifications | Female | Male | Total | Female (%) | Male (%) |
|---|---|---|---|---|---|
| Anatomy, Physiology and Pathology | 2,306 | 1,079 | 3,385 | 68.1 | 31.9 |
| Pharmacology, Toxicology and Pharmacy | 2,407 | 1,650 | 4,057 | 59.3 | 40.7 |
| Medical Technology | 1,143 | 430 | 1,573 | 72.7 | 27.3 |
| Biological Sciences: any area of study | 17 | 7 | 24 | 70.8 | 29.2 |
| Biology | 2,622 | 1,881 | 4,503 | 58.2 | 41.8 |
| Botany | 11 | 13 | 24 | 45.8 | 54.2 |
| Zoology | 757 | 401 | 1,158 | 65.4 | 34.6 |
| Genetics | 291 | 175 | 466 | 62.4 | 37.6 |
| Microbiology | 178 | 164 | 342 | 52.0 | 48.0 |
| Sports Science | 3,312 | 6,530 | 9,842 | 33.7 | 66.3 |
| Molecular Biology, Biophysics & Biochem | 1,154 | 974 | 2,128 | 54.2 | 45.8 |
| Others in Biological Sciences | 366 | 239 | 605 | 60.5 | 39.5 |
| Combinations within Biological Sciences | 256 | 221 | 477 | 53.7 | 46.3 |
| Physical Sciences: any area of study | 120 | 204 | 324 | 37.0 | 63.0 |
| Chemistry | 1,639 | 2,268 | 3,907 | 42.0 | 58.0 |
| Materials Science | 4 | 5 | 9 | 44.4 | 55.6 |
| Physics | 618 | 2,610 | 3,228 | 19.1 | 80.9 |
| Forensic and Archaeological Science | 1,143 | 638 | 1,781 | 64.2 | 35.8 |
| Astronomy | 27 | 94 | 121 | 22.3 | 77.7 |
| Geology | 501 | 870 | 1,371 | 36.5 | 63.5 |
| Ocean Sciences | 83 | 136 | 219 | 37.9 | 62.1 |
| Physical & Terrestrial Geog & Env Sci | 1,720 | 1,921 | 3,641 | 47.2 | 52.8 |
| Others in Physical Sciences | 338 | 382 | 720 | 46.9 | 53.1 |
| Combinations within Physical Sciences | 223 | 266 | 489 | 45.6 | 54.4 |
| Mathematical & Comp Sci: any area | 42 | 74 | 116 | 36.2 | 63.8 |
| Mathematics | 2,411 | 3,504 | 5,915 | 40.8 | 59.2 |
| Operational Research | 25 | 23 | 48 | 52.1 | 47.9 |
| Statistics | 76 | 128 | 204 | 37.3 | 62.7 |
| Computer Science | 1,563 | 10,119 | 11,682 | 13.4 | 86.6 |
| Information Systems | 823 | 2,514 | 3,337 | 24.7 | 75.3 |
| Software Engineering | 121 | 1,319 | 1,440 | 8.4 | 91.6 |
| Artificial Intelligence | 9 | 61 | 70 | 12.9 | 87.1 |
| Others in Mathematical & Computer Science | 17 | 65 | 82 | 20.7 | 79.3 |
| Combinations within Mathematical & Computer Science | 372 | 1,356 | 1,728 | 21.5 | 78.5 |
| Engineering: any area of study | 8 | 82 | 90 | 8.9 | 91.1 |
| General Engineering | 398 | 2,684 | 3,082 | 12.9 | 87.1 |

## Appendix continued

| Subjects to be studied for HE qualifications | Female | Male | Total | Female (%) | Male (%) |
|---|---|---|---|---|---|
| Civil Engineering | 571 | 3,375 | 3,946 | 14.5 | 85.5 |
| Mechanical Engineering | 372 | 4,559 | 4,931 | 7.5 | 92.5 |
| Aerospace Engineering | 206 | 1,667 | 1,873 | 11.0 | 89.0 |
| Naval Architecture | 10 | 129 | 139 | 7.2 | 92.8 |
| Electronic and Electrical Engineering | 552 | 4,346 | 4,898 | 11.3 | 88.7 |
| Production and Manufacturing Engineering | 189 | 587 | 776 | 24.4 | 75.6 |
| Chemical, Process and Energy Engineering | 369 | 1,096 | 1,465 | 25.2 | 74.8 |
| Others in Engineering | 1 | 10 | 11 | 9.1 | 90.9 |
| Combinations within Engineering | 63 | 640 | 703 | 9.0 | 91.0 |
| Minerals Technology | 8 | 34 | 42 | 19.0 | 81.0 |
| Metallurgy | 16 | 11 | 27 | 59.3 | 40.7 |
| Polymers and Textiles | 358 | 76 | 434 | 82.5 | 17.5 |
| Materials Technology not otherwise specified | 148 | 185 | 333 | 44.4 | 55.6 |
| Maritime Technology | 15 | 205 | 220 | 6.8 | 93.2 |
| Industrial Biotechnology | 42 | 56 | 98 | 42.9 | 57.1 |
| Others in Technology | 196 | 1,546 | 1,742 | 11.3 | 88.7 |
| Combinations within Technology | 3 | 15 | 18 | 16.7 | 83.3 |
| Architecture, Build & Plan: any area | – | 7 | 7 | 0.0 | 100.0 |
| Architecture | 1,566 | 2,240 | 3,806 | 41.1 | 58.9 |
| Building | 570 | 3,427 | 3,997 | 14.3 | 85.7 |
| Landscape Design | 85 | 135 | 220 | 38.6 | 61.4 |
| Planning (Urban, Rural and Regional) | 429 | 705 | 1,134 | 37.8 | 62.2 |
| Others in Architecture,Build & Plan | 10 | 32 | 42 | 23.8 | 76.2 |
| Combinations within Architecture,Build & Plan | 87 | 148 | 235 | 37.0 | 63.0 |
| Combs of engin/tech/building studies | 39 | 116 | 155 | 25.2 | 74.8 |
| Combs of engineering/technology | 42 | 217 | 259 | 16.2 | 83.8 |
| Combs of med/bio/agric sciences | 1,697 | 942 | 2,639 | 64.3 | 35.7 |
| Combs of med/bio/agric sciences with phys/math sciences | 866 | 634 | 1,500 | 57.7 | 42.3 |
| Combs of phys/math science with arts/humanities/languages | 895 | 1,489 | 2,384 | 37.5 | 62.5 |
| Combs of phys/math science with social studies/bus/law | 1,570 | 2,138 | 3,708 | 42.3 | 57.7 |
| Combs of phys/math sciences | 185 | 497 | 682 | 27.1 | 72.9 |
| Combs of science/engineering with arts/humanities/languages | 3,156 | 3,308 | 6,464 | 48.8 | 51.2 |
| Combs of science/engineering with social studies/bus/law | 3,766 | 2,371 | 6,137 | 61.4 | 38.6 |
| Combs of sciences with engineering/technology | 378 | 1,287 | 1,665 | 22.7 | 77.3 |
| **All Subjects Above:** | **45,561** | **83,317** | **128,878** | **35.4** | **64.6** |

Secondary analysis by UKRC UCAS (2008) Annual Data, 2007 entry: Subject dataset V2.0.. http://www.ucas.com/about_us/stat_services/stats_online/annual_datasets_to_download/. Accessed 31 October 2008 from http://www.ukrc4setwomen.org/downloads/081_STEM_enrolment_2007.xls accessed 30 March 2008, 10.38am.

A Department for Children, Schools and Families initiative to promote subject choice and careers in Science, Technology, Engineering and Maths (STEM) delivered by the Centre for Science Education at Sheffield Hallam University and VT Enterprise.



**Want to know more?**

Contact STEM Subject Choice and Careers

Email: info@careersinstem.co.uk
Tel:  0114 225 4870

The Centre for Science Education
Sheffield Hallam University
City Campus, Howard Street
Sheffield S1 1WB