STEM Choices

A Resource Pack for Careers Education and Information, Advice and Guidance Practitioners

Science

Technology

Engineering

Maths

Enthusing Students
Equipping Professionals
Supporting Employers

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Acknowledgements

This resource arises from the STEM Choice and Careers project undertaken by the Centre for Science Education at Sheffield Hallam University and VT Enterprise, on behalf of the Department for Children, Schools and Families (DCSF). The project team (Anthony Barnes, Jill Collins, Ken Mannion, Alan Moore, Pat Morton, Claire Nix and Mark Windale) would like to thank the many stakeholders and partners who have offered suggestions and resources to support its development. These include:-

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We welcome further feedback to inform the updates and supplements to this pack.

Please email us on info@careersinstem.co.uk

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

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1 Introduction

The importance of STEM and the contribution of careers education and IAG

The future prosperity of the UK is, to a large extent, dependent on young people choosing STEM-related subjects. Science, technology, engineering and maths (STEM) subjects are vital to the country's economic and social development. The role of STEM skills is to help improve the quality of people's everyday lives and find solutions to global challenges, such as sustainable economic development.

Recent research highlights the shortfall in the number of people choosing to study STEM subjects, as well as the need to double the supply of skilled workers in STEM-related jobs in the next seven to ten years.

By 2014, it is expected that the UK will need to fill around three-quarters of a million extra jobs requiring highly numerate, analytical people with STEM skills. Yet currently, six out of ten (59%) firms employing STEM-skilled staff say they are having difficulty recruiting. The low take-up of STEM subjects at university is a large part of the problem and there has been a 15% fall in engineering and technology graduates (23,300 to 19,700) over the past decade.[1]

Young people build up their knowledge and understanding of science and maths on a gradual basis. Once dropped, maths and physical science subjects are much harder to return to later. Young people can cut themselves off from a whole range of careers by not continuing their STEM education.

To tackle the decline we need to engage the interest and enthusiasm of young people, and demonstrate the relevance of STEM knowledge and skills to everyday life.

We also need to promote excitement about the UK's world-class science base in sectors including pharmaceuticals, aerospace, telecommunications, mobile phone technology, oil and gas exploration, along with the increasing demand for scientists, engineers and technicians.

As we face global recession, tutors, teachers and advisers will be cautious about promoting messages about growing demand, only for young people's hopes to be blighted when companies shed staff. There is strong evidence of continuing investment[2] in current and future STEM skills suggesting that the demand for new entrants will hold up. Future updates to this resource will analyse this trend in more detail.

1.CBI/Edexcel Education and Skills Survey 2008
2.The Government and Cogent Sector Skills Council is making £50m available for employers in the national skills council's vital science-using sector. The ring-fenced fund is aimed at both the training of new entrants and apprentices and qualifying existing workers in the chemicals, polymers and pharmaceuticals sector. The offer is directed at the specific skills needs of the sector and a range of technical qualifications which embed skills for competitiveness within companies.

We are all living in a world struggling to deal with issues of **climate change and a rising population**, with associated demands on **water supply, food production and energy.** This challenging background means that **young people** can both **build strong futures** and **make a difference** by choosing STEM subjects and careers.

Relevant National Initiatives

An unprecedented range of new and continuing initiatives by the Government, professional bodies, education–business partnerships and employers are seeking to transform the teaching of STEM subjects, promote choice of STEM courses and careers and improve public understanding of science.

Jim Knight, Minister of State for Schools and Learners, explains the Department for Children, Schools and Families' (DCSF) campaign to promote STEM subjects and careers:

The UK is standing at a crossroads. We're a world leader in research and development, in areas including clean technology, biotechnology and pharmaceuticals. The future prosperity of this country is dependent on a ready supply of skilled scientists to ensure we capitalise fully on the strength of our research and development heritage...at the moment, we simply don't have enough young people choosing science–related subjects.

Central to the campaign is the need to challenge young people's perceptions by showing them that studying science and maths subjects can set them on a path to a challenging and rewarding career. The growing demand for new technology to help fight climate change is just one reason behind the many different opportunities for an exciting and rewarding career. The UK is in prime position to capitalise on its research and development credentials – the challenge for us now is to help get young people excited about where science and maths could take them – and to provide them with the resources and support to fulfil their potential once on this path.

The introduction of the new Secondary Curriculum from September 2008 provides valuable support to exploring career learning and STEM. A programme of study for economic wellbeing and financial capability (as part of personal, social, health and economic (PSHE) education) encourages schools to help students to:

- expand their horizons for action by challenging stereotyping, discrimination and other cultural and social barriers to choice
- aim high
- build a positive and realistic view of needs and capabilities so that they can make effective learning plans, decisions and transitions
- be aware of changing career opportunities and develop the knowledge and skills to make informed decisions about learning programmes.

Guidance from the Qualifications and Curriculum Authority on PSHE curriculum provision asks schools to offer:

- specific lessons as part of PSHE
- explicit, planned content in other curriculum subjects
- whole school and extended timetable activities
- specific projects and experiences.

For the first time there is also explicit reference to the real–life application of each of the subjects, with real scope for a strong partnership between STEM subject teachers and those responsible for PSHE education and wider personal and career development. The importance statements for key STEM subjects highlights their work–related elements, for example:

Maths – important for all members of a modern society ... for its use in the workplace, business and finance ... tools for understanding economics ...essential for participation in the knowledge economy

- applications and implications of maths
- work on problems and in contexts beyond the school (e.g. financial).

Science – discover how scientific ideas contribute to technological change – affecting industry, business ...

- applications and implications of science
- experience science in the workplace, where possible.

Design and technology – skills and understanding of economic, industrial and environmental issues...evaluate present and past D&T, and its uses and effects

ICT – understanding to apply skills purposefully in learning, everyday life and employment... economic implications of its use.

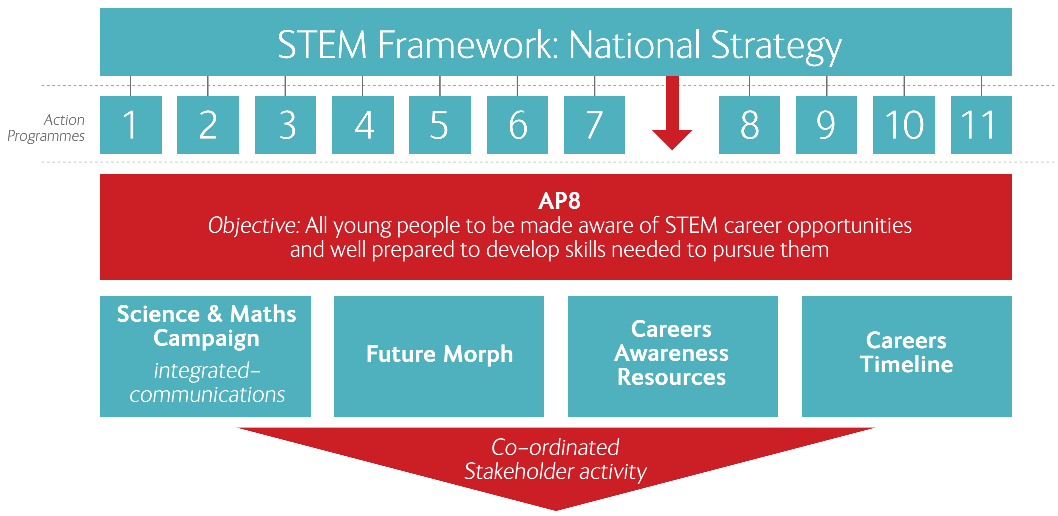
The Department for Innovation, Universities and Skills (DIUS) is actively involved in addressing skills shortages, science in society initiatives and the role and contribution of higher education to the STEM agenda. DIUS recently announced **The Science So What? So Everything** campaign which includes video clips, case studies and information to improve the public perception of science. (see http://sciencesowhat.direct.gov.uk)

The Government is supporting a network of National Skills Academies delivering the skills required by each sector of the economy. Skills Academies in the STEM arena include Construction, Food and Drink Manufacturing, Nuclear, Process Industries, Materials Production and Supply, Power and Information Technology.

The Department for Business, Enterprise & Regulatory Reform (BERR) has also recently published Manufacturing: New challenges, New Opportunities which announced the launch of a Manufacturing the Future campaign to change public perception of manufacturing and to ensure young people are aware of the exciting career opportunities available.

Action Programme Eight – Raising Awareness of STEM Careers

The Careers Awareness Programme is one of eleven Action Programmes that make up the National STEM agenda under the Director John Holman (See The STEM Framework, July 2008 http://www.stemdirectories.org.uk/docs/STEM_Framework.pdf)



The programme, co-ordinated by the Centre for Science Education at Sheffield Hallam University in partnership with VT Enterprise, seeks to tackle a number of key issues:

- Arrest the declining numbers of young people studying STEM subjects
- Improve awareness of STEM careers
- Tackle the skills gap
- Assure a more representative take-up of STEM subjects and careers in terms of age, gender, ethnicity
- Provide continuing professional development for STEM staff
- Promote activities and careers advice that bring real world contexts and applications of STEM into the classroom
- Ensure that the STEM education support infrastructure is better co-ordinated.

Kate Bellingham
The National STEM Careers Co-ordinator

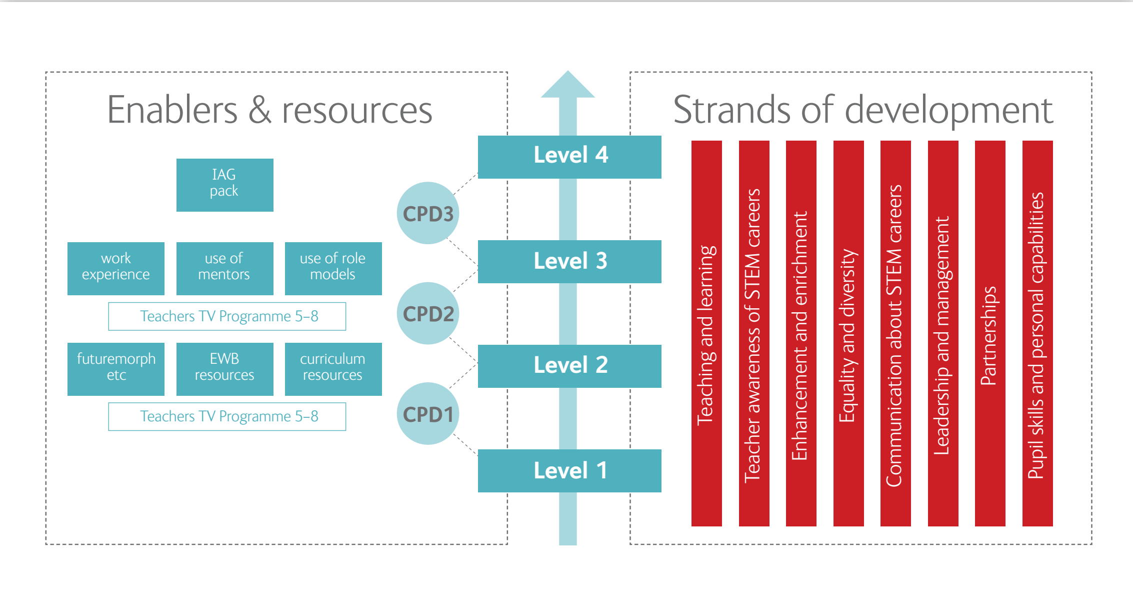
Kate Bellingham as National STEM Careers Co-ordinator is at the centre of the programme.

I'm delighted to have taken on the role of National STEM Careers Co-ordinator. I've been involved in the promotion of STEM for many years, and I know we currently have a unique window of opportunity to make a real difference to our young people in the area of STEM careers. The changes in secondary curriculum, new quality standards in information, advice and guidance, improved structure in enhancement and enrichment activities and support through the STEM Framework all provide an ideal foundation for significant change. As well as the co-ordinating role, providing a conduit for ideas and collaboration, I would like to be a 'champion' for STEM careers. Expect to see and hear me out and about promoting and supporting the campaign.

The four key strands of the programme are:

- a communications campaign to engage young people, their parents, the workforce and relevant stakeholders to improve the take-up of science and maths subjects post-16
- the Futuremorph website for young people aged 11–18 to help engage them in studying science and maths by demonstrating the huge range of career opportunities available by pursuing these subjects
- careers awareness resources for schools, teachers and careers education and IAG professionals to complement the public facing elements
- a Careers Awareness Timeline Pilot designed to establish a more coherent structure for young people to learn about careers relating to science and maths.

The chart below outlines the main strands of development for the careers awareness resources. The enablers and resources are products that will help to deliver the strands of development through the programme's continuing professional development activities.



This pack for careers education (CE) and information, advice and guidance (IAG) practitioners is central to engaging tutors, subject teachers, personal and careers advisers in the business of STEM careers awareness. It will be updated and supplemented throughout the three years of the project to help boost the confidence and readiness of front-line staff to engage with young people and their parents about STEM choices, and to give well-informed and up-to-date information on the current demand and likely future trends in relation to STEM opportunities.

The pack seeks to help CE/IAG practitioners to *broaden young people's perspectives* and to *challenge stereotyped images of sectors and occupations.* It demonstrates the relevance of STEM to everyday life, and captures the excitement and *creativity involved in developments such as:*

- mobile phone technology
- satellite navigation systems
- digital technology
- nanotechnology
- fuel cell technology
- space technology
- bioinformatics

What you can do and how the pack can help

There is a range of ways in which teachers, tutors and advisers can make a real difference to STEM careers awareness. See the key points outlined below and how the resource pack can support these tasks.

There is also a wide range of other initiatives and developments practitioners can draw on including other strands of the STEM Careers Awareness Action Programme such as role models and equality and diversity resources. Please see **Section 9**: Where To Find More Information for a signpost to other materials.

What you can do	How the pack can help
• Review your own continuing professional development needs in relation to STEM careers awareness. Credibility is a very important characteristic in the eyes of young people. They will seek and accept CE/IAG help only from those who have it! Young people value CE/IAG practitioners who have knowledge, especially insider knowledge, power and influence to enable them to access opportunities that are in their interest. The IAG standards state that IAG must be 'impartial' but there is room for positive partiality to act in the best interests of the young person.	See **Section 2:** Current and Future Trends. See **Section 5:** Where's the Money? See the Industry Focus reports and case studies in **Section 7.** These will be progressively updated through the life of the project.
• Check your own knowledge and understanding of learning routes and progression possibilities for young people in STEM-related subjects. New and expanded provision, especially Diplomas and Apprenticeships, is changing the face of local opportunities. Familiarise yourself with the resources that young people themselves are using such as the online local area prospectus. Ensure you are aware of a wide range of pathways for pupils of all abilities not just for high flyers.	See **Section 3**: Learning Routes and Pathways.

What you can do	How the pack can help
• Establish a shared understanding of the starting points and challenges in your school/learning network in relation to STEM take-up. Share general information about the perception of STEM subjects, e.g. the quality of teaching, motivation and interest of learners.	See **Section 2:** Current and Future Trends.
• Collaborate with STEM departments in your school/learning network/partnership to raise the visibility of STEM subjects and careers and to communicate that, where young people are taking STEM subjects, they are seen to be successful and enjoying themselves. Provide subject and careers information and resources for young people and their parents and carers, e.g. posters, displays in each department.	See **Section 9**: Where to Find More Information.
• Build up your knowledge of local agencies and initiatives that can support STEM-related enrichment and enhancement activities in your school and ensure that these contribute to the career planning of individual young people.	See **Section 8:** Organising STEM Events and **Section 9:** Where To Find More Information. Updates to the pack will share information from the the STEM Careers Awareness Timeline Pilot on good practice in the process of learning about STEM careers. Collaboration between careers staff and STEM staff is a key element in this work. To access the self-review and development framework being used in the STEM Careers Awareness Timeline Pilot contact info@careersinstem.co.uk Contact your regional STEM Partnership and search on 'Schemes, Activities and Projects' for examples of careers events http://www.stemcentres.org.uk/home See also STEM Directories (Science, Engineering and Technology, Mathematics) http://www.stemdirectories.org.uk/
• Motivate and engage young people by involving them in activities where they need to use their STEM knowledge, understanding and skills to discuss and make decisions about demographic, social, economic, environmental, medical and security challenges facing us, e.g. food, water, energy.	See Industry Focus reports and case studies. See also **Section 9**: Where To Find More Information for links to futuremorph. See **Section 6**: Making presentations for group work ideas.

What you can do	How the pack can help
• Challenge stereotypes. CE/IAG practitioners can help young people extend their 'horizons for action'. Often young women and black and minority ethnic students are under-represented in STEM courses and careers and may be held back by poor information and lack of positive role models.	See **Section 4**: Equality and Diversity. The first edition of the pack focuses on women. Subsequent updates will address inclusion issues in relation to other groups.
• Contribute to thematic learning projects, e.g. collaborate with citizenship teachers to explain how science is regulated to protect the needs and interests of citizens.	See **Section 8**: Organising STEM Events.

2 CEIAG Professionals' Guide

- Current and Future Trends
- The International Perspective

Current and Future Trends

1. A changing labour market

As the table below shows, the UK has changed from a predominantly manufacturing and agricultural–based economy to one that is increasingly service based:

	Manufacturing	Services
1950	9 million employees	9 million employees
1986	5.2 million employees	18 million employees
2006	3.3 million employees	25 million employees

One of the results of this is that the number of jobs in semi-skilled or unskilled work is declining. Employers are increasingly looking for people with higher level qualifications to fill clerical, technical and professional level work:

- In 1960, 8 million or 33% of the labour market was in unskilled or semi–skilled jobs.
- In 2006, 3.5 million or 12% of the labour market was in unskilled or semi–skilled jobs.
- In 2007, the Treasury forecast that by 2020 just 600,000 or 2% of the labour market would be in unskilled or semi–skilled jobs.

2. An ageing population

In the UK, the number of over 65s is predicted to increase from 8.5 million in 2000 to 12.3 million by 2025 and 15 million in 2050. This will place growing pressures on the health and medical services in particular. As a result, there will be *increasing demand for people with STEM skills,* with exciting opportunities in areas such as:

- *Biomedical engineering* – designing hip and knee replacement joints, heart bypass valves, breast implants
- *Bioinformatics and computational biology* – solving biological problems at a molecular level such as DNA sequencing in the treatment of cancer to target individual cells
- *Pharmaceutical research* – working to develop new drugs to combat the effects of cancer, tackling mental health issues, vaccines, insulin, antibiotics
- *Biotechnology* – using living cells (bacteria, yeast, stem cells) as well as biological substances (enzymes) in industrial processes like brewing and baking, and in research in agriculture and medicine.

3. A STEM skills shortage

The CBI Education and Skills Survey of 2008 states 59% of employers recruiting STEM staff are experiencing skills shortages. Between 1997 and 2007 there was a decline by 15% in the number of students graduating in technology and engineering subjects and that, as a result, employers are increasingly looking overseas to fill the shortfall. Updates to this pack will share emerging trends in the demand for STEM skills against the backdrop of a global recession.

The CBI predicts that by 2014 the UK will need an *extra 730,000 people with STEM qualifications* compared to 2007. Growth areas include:

- *Nanotechnology* – the science of the very small enabling the development of light and immensely strong materials with varied applications including telecommunications, aviation, fuel cells
- *Space technology* – developing satellites for use in, for example, telecommunications, global positioning systems, military surveillance
- *Civil and water engineering* – needed to design and construct, for example, flood defences, improved irrigation systems, dams, desalinisation plants
- *Ubicomp technology* – designing and building micro–processors and low cost sensors into, for example, central heating systems, refrigerators, and security systems to enable use by remote control.

4. Climate change

The Climate Change Bill 2007 sets a 2050 target of reducing UK carbon emissions by 60% compared to 1990 levels. The report calls for a whole range of measures including:

- carbon capture and storage
- a new generation of nuclear energy
- greater energy efficiency
- renewable sources of energy
- a second generation of biodiesel fuels

To meet the challenge of climate change, there is a need to *boost the number of people with STEM skills at all levels* in order to achieve these targets and meet the demand for skills that these technologies will create in areas including:

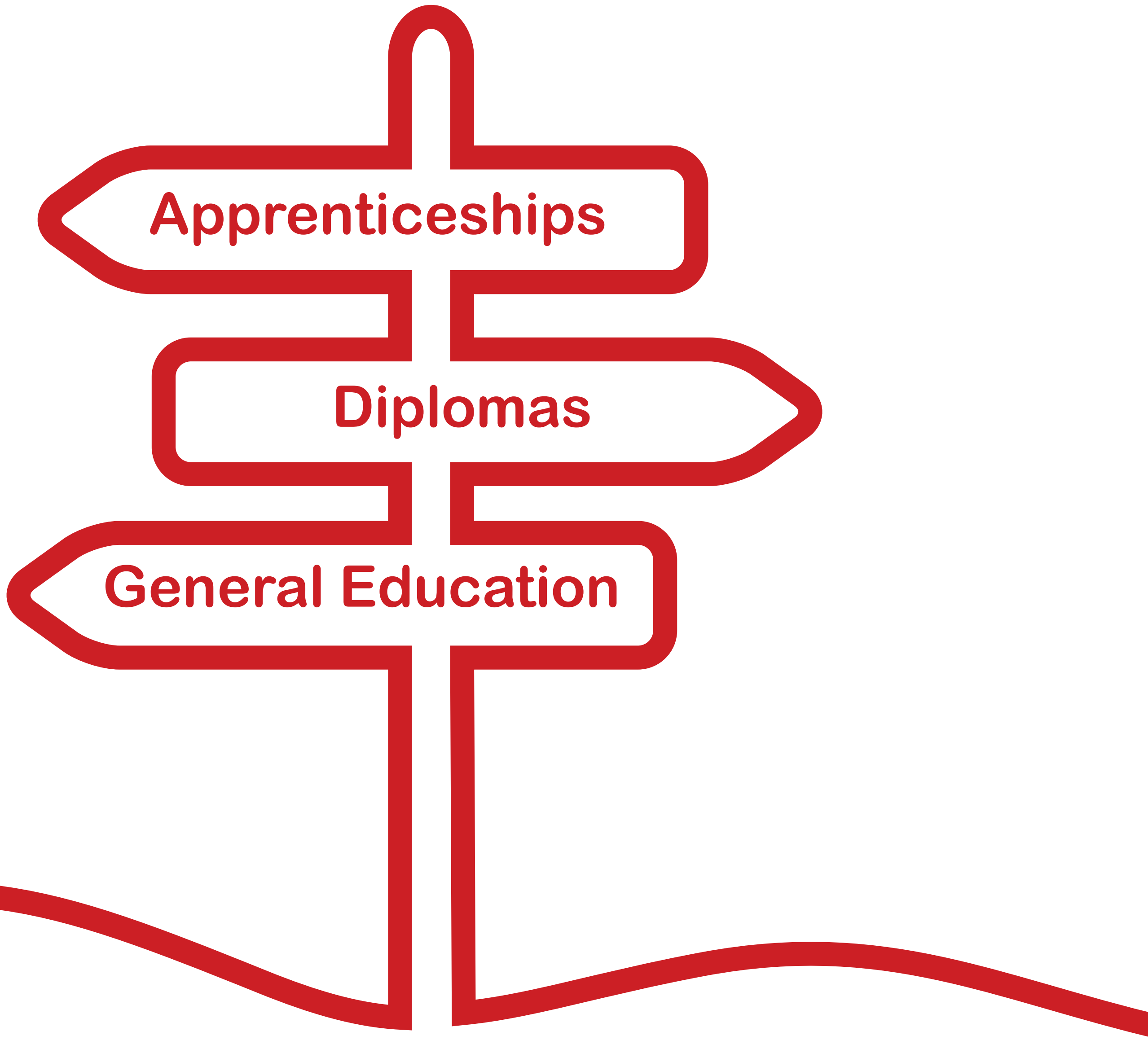
- *Renewable energy technology* – generating electricity from renewable sources such as wind, solar and tidal power
- *Clean coal technology* – building new coal–fired power stations where carbon emissions are reduced and stored underground
- *Nuclear engineering* – needed for the programme of decommissioning old plants and building new nuclear power stations over the next decades
- *Fuel cell technology* – fuel cells combine hydrogen and oxygen to produce water, electricity and heat – a potential alternative energy source that is cleaner and more efficient than using non–renewable fossil fuels.

The International Perspective

The economic growth of Asian countries, particularly China and India, is challenging a two hundred year dominance by Europe and the USA. A Goldman Sachs Economic Unit forecast in 2006 that the Chinese economy would surpass that of the US by the early 2040s, with the Indian economy not far behind. The team has recently updated this to predict that the Chinese economy will overtake the US economy by circa 2025, and be twice as big, in terms of Gross Domestic Product, by 2050.

China and India are the two most heavily populated countries in the world, with a combined total in 2008 of 2.4 billion people out of 6.6 billion (adding up to 36% of the total world population). These two countries with their large domestic markets will increasingly dominate the world economy.

In order for the UK to remain competitive in this changing global economic reality, there is an ever greater need for people with STEM skills to continue technological advancements and sustain standards of living.



3

Learning Routes and Pathways

Keeping future options open by choosing a STEM learning route

General Points

Exciting opportunities are opening up for young people to develop their STEM skills and unlock talent through the following learning routes. All routes support progression to higher level learning and employment:

- Apprenticeship route – is being expanded and strengthened
- Diploma route – this new qualification combines classroom learning with practical hands–on experience covering a broad employment sector
- A Levels – are being updated and strengthened to ensure they maintain their high standards and meet current needs. Some career options specify particular subjects as entry requirements, for example, to be a forensic scientist you need biology or chemistry, and physics is an ideal option for sound engineering.

Apprenticeships

- Apprenticeships are being reformed. They are vital to give young people the skills they need to succeed in the global economy
- A greater allocation of funding is being provided for Apprenticeships, building on the Government's Skills Pledge to support the drive for increased skills to make the UK workforce more competitive. There is currently a skills shortage in processing and technician roles and this will increase significantly in the period up to 2017, which coincides with the lowest number of 16 –18 year olds in the population
- New frameworks are being developed and existing frameworks are being reviewed in response to the needs of employers.

Apprenticeships which include STEM skills can be found in a diverse range of sectors, as shown in the following examples:

- Administration and Professional – Accounting Apprenticeship
- Construction – Electrical and Electronic Servicing Apprenticeship
- Engineering – Heating, Ventilating, Air Conditioning and Refrigeration Apprenticeship
- Finance, Insurance and Real Estate – Providing Financial Services Apprenticeships
- Food and Drink – Food and Drink Manufacturing Apprenticeships
- Manufacturing – Chemical, Pharmaceutical, Petrochemical Manufacturing and Refining Industries Apprenticeships
- Transportation – Rail Transport Engineering Apprenticeship

For more details and to find a full list of Apprenticeships visit www.apprenticeships.org.uk

Diplomas

www.diploma-support.org and www.sciencesowhat.direct.gov.uk

Diploma is a qualification that:

- offers a mix of classroom learning, creative thinking and practical hands-on experience
- involves a research-based project and at least 10 days' work experience with an employer
- covers a broad employment sector and builds essential skills while keeping all learning routes open
- has been developed in partnership with employers and higher education institutions.

The Diploma is available at three levels:

- *Foundation Diploma* – is a level 1 qualification that is the equivalent of 5 GCSEs
- *Higher Diploma* – is a level 2 qualification that is the equivalent of 7 GCSEs
- *Advanced Diploma* – is a level 3 qualification that is equivalent to 3.5 A Levels. This level also has a Progression Diploma, which is the equivalent to 2 A Levels.

By 2013 all students will be entitled to access all 17 Diploma subjects. The Diplomas relating to STEM skills available:

From September 2008:

- Construction and the Built Environment
- Engineering
- Information and Technology

From September 2009:

- Business, Administration and Finance
- Manufacturing and Product Design

From September 2011 Science at Foundation and Higher Level and from September 2012 at the Advanced Level.

STEM A Level subjects

In terms of numbers of students studying STEM A Levels, the figures are as follows:

Physics **–** from a high in 1982 of 58,000 students, numbers had declined to just over 27,000 by 2007

Maths **–** has shown a slight decline from 67,000 in 1996 to 60,000 in 2007

Chemistry **–** has remained more or less level at around 40,000 over the past ten years

Biological Science **–** has been a more stable area over the years; in 2007 there were 54,000 A Level entrants, making up 6.8% of the total number of A Level entries, and double the number taking A Level physics

Other Science subjects **–** significant growth in A Level entrants has occurred in the past twenty years in some science subjects. For example, in 2007, **psychology** had 52,000 entrants and there has been a similar dramatic rise in the number of students taking A Level **sports science/studies.**

STEM degree subjects

Applications

The number of overall university applicants rose by 12.2% between 2002 and 2007, but STEM subject applicants rose by just 0.08%. Subject trends in degree course applications are as follows:

Physics **–** has seen an encouraging rise in applicants from 12,830 in 2002 to 14,935 in 2007, but this is a very low base compared to e.g. psychology with 72,475 applicants in 2007

Maths **–** has seen a growth in applicants from 20,120 in 2002 to 28,590 in 2007

Chemistry **–** a stable number of applicants from 19,015 in 2002 to 19,585 in 2007

Biological Sciences **–** has attracted the largest number of applicants of all the STEM subjects, with a rise from 125,860 in 2002 to 164,215 in 2007; however, over two–thirds of the applicants are choosing psychology and sports science degree courses

Engineering and Technology **–** has shown a rise in applicants from 131,505 in 2002 to 140,580 in 2007.

Acceptances

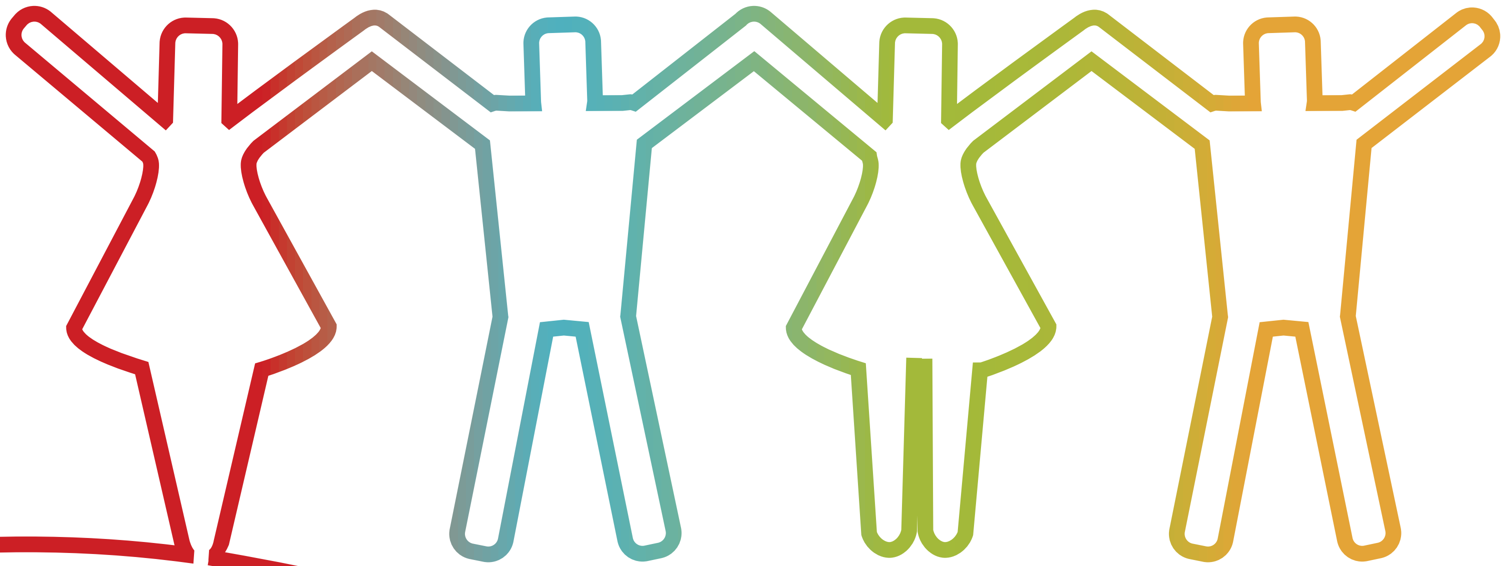
The table below indicates the number of acceptances onto STEM degree courses, and illustrates the low base of STEM degree numbers compared to more popular subjects such as psychology and sports science.

Degree subject	Number of acceptances in 2008
Physics	3,040
Maths	5,682
Chemistry	3,545
Biology	4,000
Mechanical engineering (the largest single engineering sub-discipline)	4,181
Psychology	12,908
Sports science	7,694

(Sources: Universities and Colleges Admissions Service (UCAS) and the Higher Education Statistics Agency (HESA)

Although the number of STEM graduates is lower than for many other subject areas, there is a much better chance of STEM graduates entering employment within that sector. Conversely, the number of, for example, psychology or sports science graduates entering employment directly related to their degree subject are significantly lower, as those employment sectors are much smaller.

The added value of a STEM degree is the flexibility that it brings in terms of employability. The CBI (Confederation for British Industry) Education and Skills Survey, 2008 found that there is high demand for STEM graduates in all employment sectors – with 92% of firms wanting people with these skills. Therefore, studying STEM subjects not only maximises career options in the STEM area, but also for careers not related to STEM.



4 Equality and Diversity

Promoting STEM learning routes and careers in a postive way to encourage under represented groups to see the benefits of STEM options

The STEM workforce is not yet truly representative, with a significant gender imbalance in many areas. To help address this, major investments have been made in STEMNET (Science, Technology, Engineering & Mathematics Network) and the SEA (Science & Engineering Ambassadors) programme with 19,000 ambassadors now acting as role models, while DCSF (Department for Children, Schools and Families) sponsors the science and engineering after school clubs run by STEMNET.

Barriers to females choosing STEM subjects and careers

An Institute of Physics report (December 2006), Girls in the Physics Classroom, examined how children's views of STEM develop as they grow up and why girls' participation in school science declines with age. Teaching that is not sensitive to gender may contribute to the gender gap in take-up beyond 16 of the physical sciences and maths, lessening the chances of the workforce being truly representative.

Key factors include:

- A decline in many girls' self-belief in their abilities in science, particularly the physical sciences
- Many girls reject the stereotypically masculine images of science and scientists as one they could adopt for themselves
- 42% of girls enjoyed science compared with 63% of boys
- 6% of girls reported that science was their favourite subject compared with 37% of boys
- 63% of girls said they liked biology, and this fell to 37% for chemistry and 22% for physics

To help to counteract this imbalance, a range of international studies indicate the need to change the curriculum, and the teaching and assessment methods, so as to increase girls' engagement with science.

Key recommendations include:

- Using a variety of social situations and contexts to illustrate scientific problem solving – using topics to show how science impacts on people
- Representing science as something people do and not just 'a body of knowledge'
- Using discussion as a means of showing the impact of science on life.

Other factors which influence why females do not choose the STEM option, include:

- If there is little or no actual knowledge and experience of what STEM occupations can offer, girls and women will inevitably exclude them as a realistic career choice
- For many parents their image of the STEM industries may be negative so they feel unable to support their daughters' desire to pursue a career in STEM
- Some members of various religious faiths may perceive STEM careers as being incompatible with a woman's role and religious responsibility e.g. working in a male dominated environment
- Early home life, the media and education play a crucial role in preparing children for their roles in life. Gender stereotypical roles will have been reinforced in many ways, before girls even make their career choice.

In relation to aspirations, the report concluded that girls' and boys' job ambitions across the ages reflected traditional employment patterns, and jobs traditionally undertaken by men were still those for which physics was considered most appropriate. Students' lack of knowledge of careers is a problem and increasing their awareness of physics–related careers would enable them to make informed course choices. These findings relate to the general STEM experience, and it is important that at Key Stage 3 girls should know about the wide range of careers available to them if they opt for a STEM pathway.

Gender imbalance in STEM careers

Encouraging the greater participation of females in STEM makes good business sense since by not tapping the skills potential of females, employers are reducing the pool of possible recruits.

Fewer girls choosing STEM subjects leads to gender stereotyping in education with resultant occupational segregation in the workplace. Occupational segregation is one of the three main factors contributing to the gender pay gap alongside pay discrimination and unequal impact of caring.

Without more females choosing the STEM route, occupational segregation will reinforce the current situation whereby 75% of working women are still found in just 5 occupational groups:

- Associate professional and technical (e.g. nurses)
- Administration and secretarial work
- Personal services (e.g caring for children or the elderly)
- Sales and customer service
- Non–skilled manual work.

Occupational segregation can also be illustrated by the number of 'starts' in selected Apprenticeships, as in the table below:

Gender gaps in the number of 'starts' in selected Apprenticeships (2005/06)

Selected Sectors	Women ratio (%)
Early Years Care and Education	96.0
Hairdressing	91.3
Health and Social Care	89.8
IT Services and Development	4.5
Engineering	3.7
Plumbing	1.2
Vehicle Maintenance and Repair	1.0

The Gender Pay Gap

Pay rates in male-dominated sectors are higher than in those sectors where the majority of females work:

Mean annual pay (gross) – 2006	
Selected sectors	**Mean annual pay**
ICT Professionals	£39,228
Engineering Professionals	£34,839
Hairdressing and Beauty Salon Managers and Proprietors	£18,661
Healthcare and Related Personal Services	£12,108
Childcare and Related Personal Services	£9,405

The message of overall better pay in the STEM area, combined with the exciting opportunities that are available, may encourage more girls to break this cycle of occupational segregation.

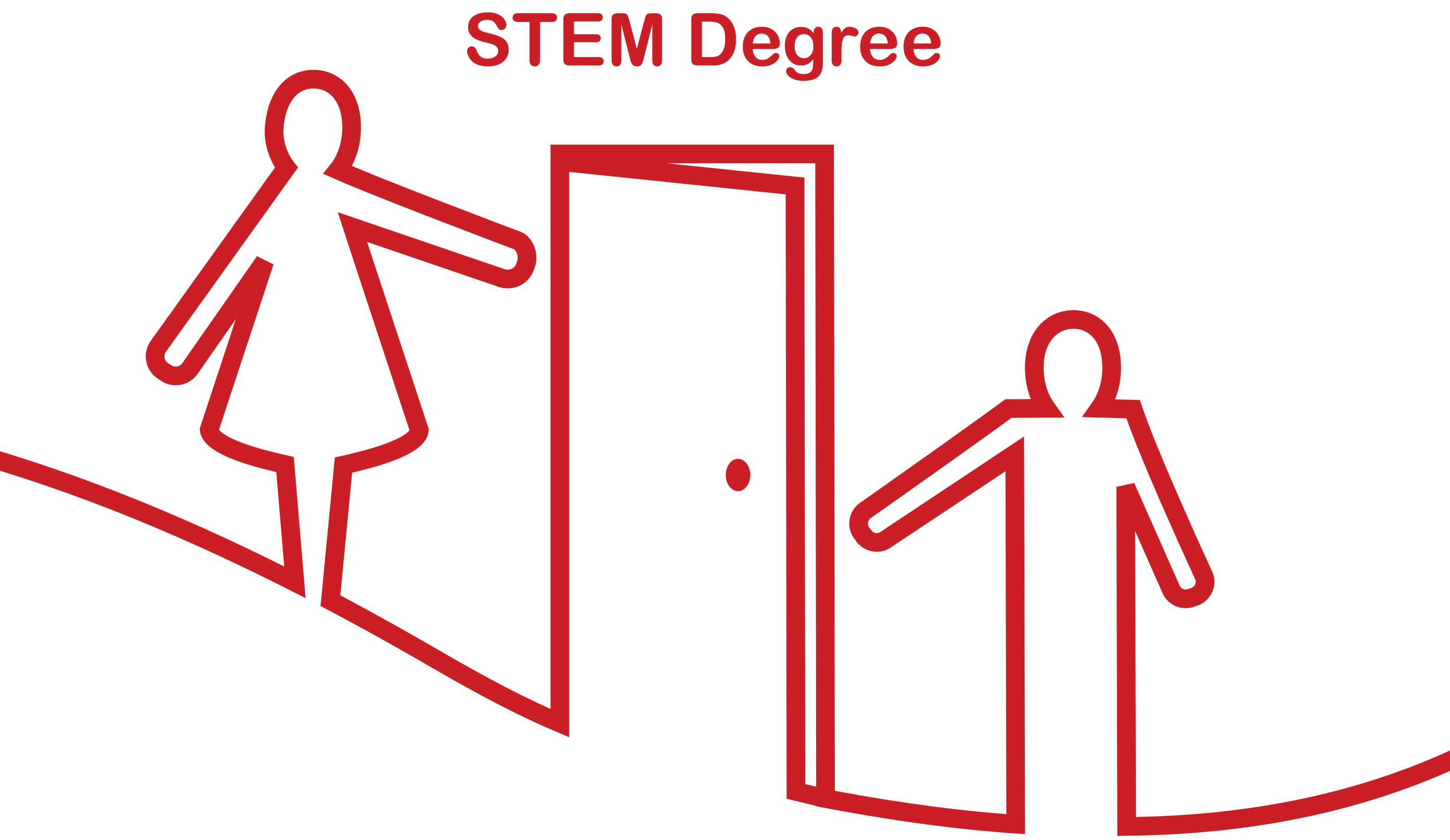
STEM Apprenticeship Opportunities

To combat the skills shortages in STEM processing and technician roles, a major expansion in Apprenticeship opportunities is taking place which may also encourage more girls to consider the STEM route. To exemplify this, the Advanced Apprentice category at the 2008 National Employer Service (NES) Learners First Award was won by Rachel Hoyle, an apprentice with BAE Systems in Lancashire. To underline the attraction of STEM opportunities and of Apprenticeships in particular, Rachel commented – *'I wanted a career where each day would be different and I could problem solve and continue to develop my skills. What was more I could continue to learn while I worked'.*

STEM Degrees

There is still some way to go before students taking STEM Degrees (with the exception of medicine, chemistry and biosciences) are truly representative of all young people.

Traditionally only a small proportion of STEM graduates have been female, and although this position has slightly improved, the gender gap in STEM graduates is still considerable. Since 1997 women have formed an increasing proportion of STEM graduates in all subjects apart from mathematical sciences. Overall the female proportion of the stock of STEM graduates has increased from 27% to 36% between 1997 and 2004. However, the female proportion of STEM graduates still falls well below the non–STEM figure of 53%. In particular, the proportion of mathematical sciences has fallen by 2% to 25%, but the weakest female representation occurs in engineering where, despite an increase of 3%, only 7% of graduates are female.



Improving Equality and Diversity Practice

In order to measure the effectiveness of work in relation to promoting equality and diversity in STEM the following framework sets out four different levels of performance and provides a ladder of progression

Level 1 – low level impact

Level 2 – some awareness and use of STEM activities

Level 3 – widespread knowledge and use of STEM activities

Level 4 – whole school approach to supporting STEM activities

Level 1

Equality and diversity

No explicit plan to tackle limited and stereotypical views of STEM courses and careers.

Level 2

Equality and diversity

Efforts made to tackle student and parents' stereotypical views of STEM courses and careers by some teachers through role models and curriculum materials.

Level 3

Equality and diversity

Active use of role models and mentors to promote equality in STEM subjects and careers.

Plans in place to deliver an inclusive STEM curriculum.

Level 4

Equality and diversity

Whole school approach to engaging all students in successful experiences of and progression in STEM. Differentiated activities to help disadvantaged students overcome barriers.

20 ways to make STEM careers advice women friendly:

Gender equality training materials can be found on www.ukrc4setwomen.org/html/education/careers-professionals. An example, '20 ways to make STEM careers advice women friendly' follows:

1. Referral

Careers advisers may not know all available information about careers that are less common than traditional areas of work.

Be aware that you don't know the whole picture and ensure you know someone who does or where it can be found. Keep an up to date list of women role models / organisations / support networks to help give the real picture.

Put together a network of "Women's Support Resources Register" in your area – "Women friendly" courses, employers, support networks, taster courses etc.

Expand the basic information you have in a useful way e.g.

(a) Develop a database of "women friendly" employers in the area and keep it up to date. Contacts can move on.

(b) Develop a register of women role models in your area.

2. Promotional Material

Ensure literature/posters have positive images and are not exclusively male dominated and unimaginative. Many resources are available e.g. UKRC, WiSET at Sheffield Hallam University, or set up your own with your own students and past students. Challenge those organisations that send stereotyped literature for you to use in a positive way to help them change. Many do not realise what they are doing. Real examples help to show it is possible.

3. Stepping Stones

Ensure you have information on stepping stones and routes, so that young women can see a progression and are not steered to a dead-end situation.

Colleges and universities are keen to widen participation to education and training, and a number of new routes to becoming qualified are opening up. There may be ways to work with those without qualifications to find a suitable pathway.

4. Employer Visits

Preparation and debriefing for visits and employer visits is essential. The impressions made on a single visit can harm or help the image gained of a profession by impressionable young women who might lack confidence. Ensure the employer is encouraging and not going to reinforce stereotypes. If something goes wrong, then a good debrief with the group can help debate the issues and an alternative could be arranged to give a different perspective. Ensure you have back up material/alternatives to counteract negative input from guest speakers. A panel can help to balance views rather than relying on a single perspective.

5. Selling Trips

Think of creative ways to sell trips and visits to technical workplaces to the girls. Try and make them interesting. A number of universities are keen to welcome girls onto non–traditional courses, and will go out of their way to make you welcome. If there are major construction projects going on in your area, find out about potential visits – and if they already have women working on the site. Find out how pupils are chosen for trips from classes/schools. Try and be involved to ensure equity and that girls get offered the trip to the "construction site" in an appropriate way.

6. Different Ways

Work in youth clubs with theatre groups or invite theatre groups into school to challenge stereotyped career choices, and have back up information to provide advice. Look for ways of using different materials in different parts of the curriculum, not just careers, taster days, role play or What's My Line.

7. Support and Encouragement

Always leave them with a clear idea of how they can be proactive in achieving their goals, making use of action plans and a step by step approach can support this, e.g. a taster day, talk to a mentor, talk to teacher or family, know the academic requirements etc.

For every negative, think of a positive, e.g. 'being cold – great pay'.

In a 'one to one' interview, be clear about difficulties that may be faced when entering a non–traditional career area. However ensure that you confirm their right to be in that area, and give them the links and safeguards to handle any difficulties.

Organise group sessions to cover issues that are important, e.g. equal opportunities in the workplace – difficulties can be discussed. Make use of women only group sessions to discuss certain issues, e.g. feeling isolated in workplace/support. Work with boys only groups can also tackle stereotyping and challenge attitudes that inhibit girls' choice.

8. Staff Development Training

Staff Development Training/INSET can be helpful to work with staff to challenge often unconscious barriers in attitude and language which can put off prospective entrants to the career before they start. Staff development training can also raise awareness of staff in other subject areas that will influence student choice. Let's TWIST / UKRC can provide purpose delivered sessions, or you may wish to run some workshops yourself, with some help from others who are interested.

9. Parents

Think of ways of involving parents – girls who are interested in a non–traditional career on a taster day are influenced by attitudes of parents and without support / knowledge might be reluctant to get involved. Parents who are involved can offer support to their daughters.

Invite parents to presentations after taster days. Invite parents to hear from women role models.

10. Mentoring

Mentoring projects can help show that women exist in many non–traditional areas. Set up a mentoring project in school, you can make links with a local college, university or employer. There are a number of established schemes that are running to draw on for advice. UKRC can help. The mentors will of course need training, and evaluation of the scheme will ensure it actually works.

11. Taster Days

Taster days can be exciting when seen as something different. They need to be active, so they are not seen as routine and boring. Make them attractive by including some excitement and lots of activity, rather than passive listening e.g. design a nursery, survey a house, build a bridge. Colleges and universities are keen to make contact with groups of under–represented students.

12. Technology and Terminology

Research indicates that girls are often put off by what they see as hard words that seem unattractive. The creative side of non–traditional areas of work should be stressed.

Think about aspects of activities that will appeal to girls who are put off by the macho image of science and technology. Sometimes the words 'technology' and 'technical' turn them off, but designing / making things, helping people, making a difference to the environment can be more attractive.

Be aware that there are a wide range of careers in these areas that are mainly about communication and people – traditionally seen as feminine skills.

13. Relating Careers to Interests

Tracking young people through interests and activities can be helpful to identify interests in non–traditional areas which can then be nurtured and encouraged e.g. an interest in drawing can be developed to architecture or painting and decorating, or engineering. Taster days can be linked to interests e.g. sports and leisure tasters with careers in non–traditional areas.

14. Confidence Building

There is a need to be supportive to students who lack confidence in taking the plunge to try something different. Support systems need to be set up not just to encourage young women to try things, but also to support them when they are challenged by others. This could mean staff being ready to challenge stereotypical views, or just having group work or sessions to deal with issues. Research shows that this initial confidence building is key to success.

Positive encouragement is always important. Be careful not to reject any career idea out of hand that the girl has, e.g. pop star, footballer. Just explore them and have a realistic back up plan, e.g. sound engineer, sports scientist.

15. Labour Market Information

Ensure your labour market information is up to date with skill shortages in your area, to make the chance of career accessible, e.g. construction skill shortages, IT and electronics shortages. These shortages provide an ideal market for working with employers who may not have considered women trainees. Have real examples available to show success e.g. "Sally 42 has 6 children and was engineer of the year, you can talk to her about it."

16. Work Experience

Research shows that entry into non–traditional careers by women is often initiated by a positive experience in work shadowing. Likewise a number of professional institutions and training organisations are keen to provide suitable work experience to promote their work areas to women and girls e.g. NHS Careers. Contact these institutions to find local employers who can provide work shadowing experience.

17. Broadening the Issues

The wider issues around work may be barriers to women entering non–traditional areas. Ensure that these barriers can be discussed and ways to overcome them can be provided. Barriers include flexible working hours and carer and childcare responsibilities (can equally apply to men). Use the experience of employers who tackle these barriers and are comfortable with them e.g. Jaguar, Leicester City Council, Connaughts.

18. Feedback

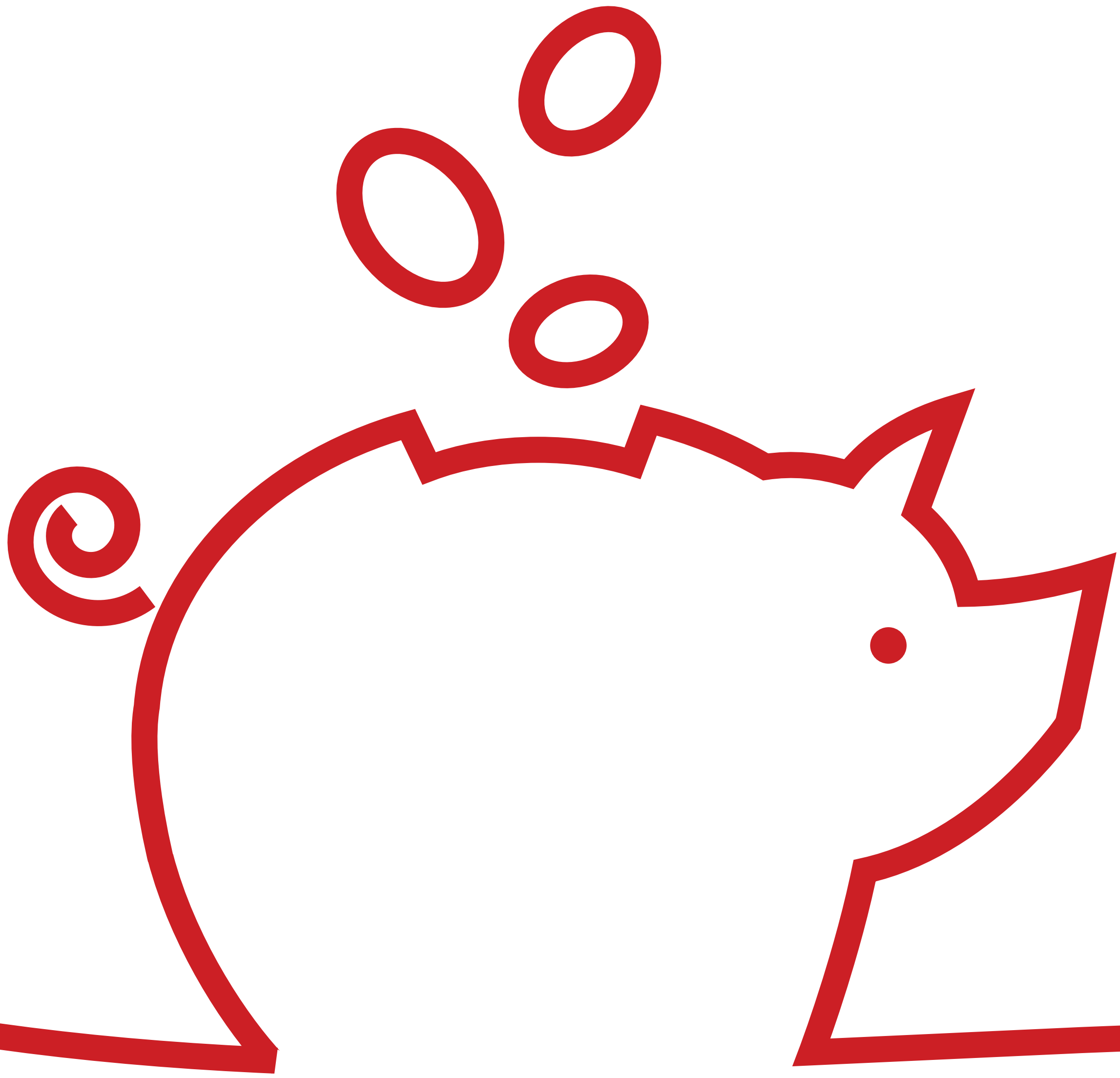
One of your best resources is your own success stories. Ensure you follow up your referrals and keep track of those who have gone on to a successful career. By using feedback sheets and getting informal feedback, you can find out any additional barriers, and seek out any problem areas or employers that can be avoided or sent information about improving their practice.

19. Racism and Sexism

The construction industry has had a reputation for being sexist and racist, and this has often acted as a barrier for careers advisers in suggesting this area of work. There is a wide ranging set of initiatives that are tackling the image and the reality of construction. Check out http://www.bconstructive.co.uk/ website to find out more. Check out locally funded projects and groups that support others like Architects for Change and Women in Property.

20. Exercises

A questionnaire sent out to careers advisers and teachers suggests that there is a need for additional exercises in working with groups to challenge stereotyping of career choice for girls. One exercise produced by a teacher for a sixth form group provides background material on related issues and gives some issues to consider e.g. "employers have a right to choose who they want for jobs," "the problem starts much earlier – it's too late by the time we get them." These are relatively simple to set up, but there is a need for sharing information and pooling of resources. If you have a good idea – and are willing to share it – contact Let's TWIST/ UKRC.



5 Where's the Money?

Illustrating the earning potential of STEM careers

It is important to dispel the myth that financial rewards for STEM graduates are poor. There has been a rapid rise in the number of students studying for a degree in the UK, but there is significant variation in the value of different degree subjects. STEM graduates fare considerably better than the average graduate, both in terms of enjoying higher annual earnings and in finding a graduate-level job.

Economic benefit from taking a STEM degree subject

There is a higher lifetime graduate earnings premium (premium refers to the percentage by which the hourly earnings achieved by degree holders exceed that achieved by individuals in possession of two or more A Levels) for STEM degrees compared to all degrees. Research suggests that the subjects of maths, physics, chemistry and engineering all have significantly higher lifetime earnings benefit than that the average for all degrees. The table below shows the additional lifetime earnings for STEM subjects compared with all degrees.

Subject	Additional Lifetime Earnings
Engineering	£220,000
Chemistry	£186,000
Physics	£188,000
Maths	£220,000
Biological Sciences	£110,000
All Degrees	£129,000

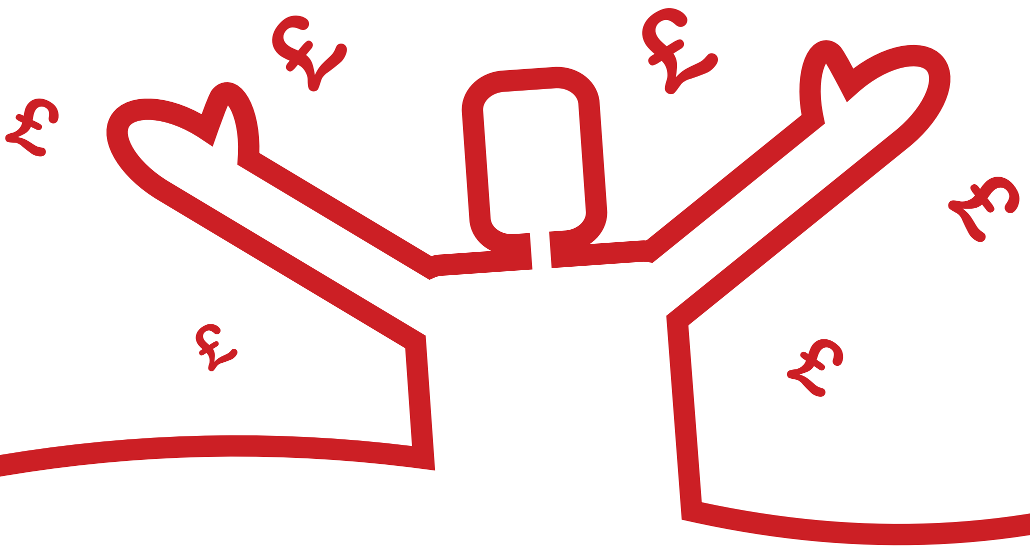
(Source: The Economic Benefit of Higher Education Qualifications produced for The Royal Society of Chemistry and the Institute of Physics by PricewaterhouseCoopers LLP, January 2005)

To give the above figures more perspective, the research indicated that history and English graduates achieve additional lifetime earnings of less than £100,000.

Recent evidence has suggested that around one third of graduates fail to get a graduate–level job (McIntosh, 2005; Chevalier and Lindley, 2007). For STEM graduates, however, the difficulties in getting good pay and a graduate–level job are much less of a problem. The tables below show the top paid degree subjects, compared to the bottom, for men and women respectively. In each case, the wage premium shown is relative to the average earnings of an arts graduate. There is a substantial variation in the earnings of graduates with different degree subjects. For instance, men with electrical engineering degrees earn in excess of 40% more than the average arts graduate. The figures suggest that employers place a higher value on graduates offering a technical or mathematically–based degree. Graduates with weaker numeracy skills tend to fare worse than their more numerate peers.

The wage premium for some degree subjects (compared to an arts degree) for men

Subject	Mark-up from average arts graduate earnings	Rank
Accountancy	42.15%	1
Electrical engineering	40.73%	2
Maths and computing	37.23%	3
Mechanical engineering	33.71%	4
Social sciences	14.20%	21
History	11.69%	22
English	10.84%	23
Sociology	10.83%	24



The wage premium for some degree subjects (compared to an arts degree) for women

Subject	Mark-up from average arts graduate earnings	Rank
Accountancy	37.12%	1
Medicine and related	27.52%	2
Law	23.97%	3
Education	22.40%	4
Psychology	1.98%	21
Biology	1.60%	22
History	0.95%	23
Politics	– 0.91%	24

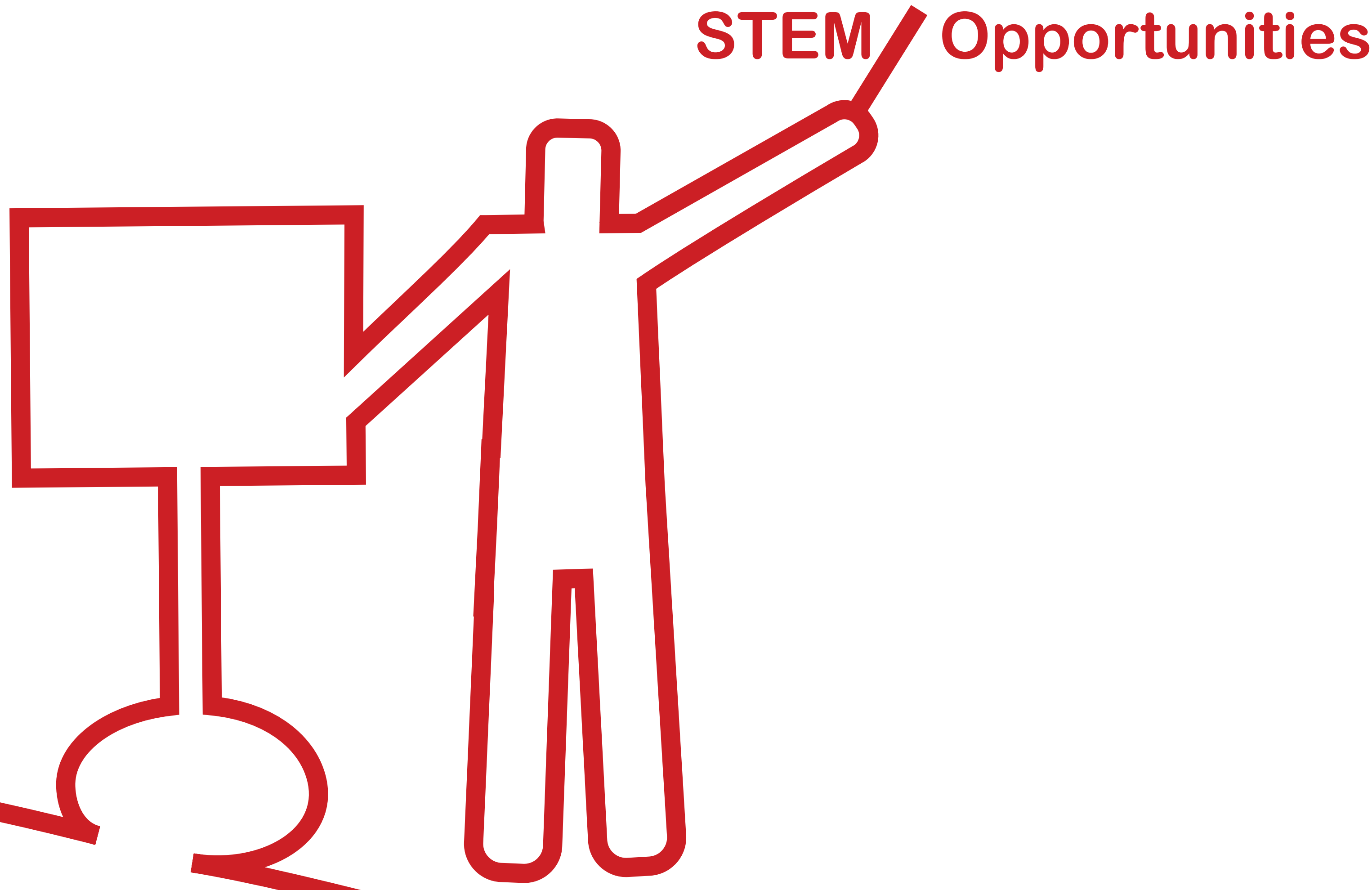
(Source: Sloane P J and O'Leary N C, 2004)

STEM salaries for non-graduate entrants

For non-graduate entrants into STEM-related occupations, the financial rewards are also above the average. The table below gives some examples by occupational sector:

Occupational sector	Average annual salary
Engineering technicians	£30,930
Electrical trades	£28,029
Science & technology associate professionals (e.g. lab technician)	£27,285
Telecommunications engineers	£27,134
All sectors	£26,020

(Source: Annual Survey of Hours & Earnings, Office for National Statistics, 2008)



6 Making Presentations

Using key facts to show the impact of STEM in dealing with today's challenges; group work ideas

Examples of emerging STEM-related opportunities – a stimulating introduction for a STEM group session that illustrates exciting developing career areas backed up with real life case studies – **YOU CAN MAKE A DIFFERENCE**

Nuclear Energy

With the commitments to build several new nuclear power stations over the next decades and the requirement to decommission numerous others, there will be a continuing demand for employees in this industry including ***nuclear engineers, nuclear physicists, chemists, material scientists and mechanical engineers*** ➡ LINK TO CASE STUDY Page 6.5

Renewable Energy

The UK government is planning to have 15% of the country's energy covered by renewable sources by 2020, centred on a major expansion in the number of wind turbines. Renewable energy will create jobs for ***civil engineers, physicists, power engineers, electrical and electronic engineers, as well as graduates from renewable energy technology courses*** ➡ LINK TO CASE STUDY Page 6.7

Biomedical Engineering

This developing area of medical technology involves the design and manufacture of items such as the replacement of knee and hip joints, heart by–pass valves, pacemakers, breast implants and artificial hearts. Degree courses are looking for A Levels or equivalent in subjects like ***maths, physics, biology or chemistry*** ➡ LINK TO CASE STUDY Page 6.9

Nanotechnology

Nanotechnology is the science of the very small. For example, carbon wire produced by nanotechnology is stronger than steel but does not melt, making electronic processes faster. Relevant subjects include ***molecular chemistry, applied physics, maths, and chemical, mechanical, biological and electronic engineering*** ➡ LINK TO CASE STUDY Page 6.11

Computer Games Design

The applications for computer games go beyond home entertainment to include therapeutic and medical treatments. For example, patients suffering from strokes can use video games to gain movements in their limbs affected by paralysis. A high level of ***maths*** is needed for this area, as well as specialist ***systems engineers*** ➡ LINK TO CASE STUDY Page 6.13

Space Technology

There are approximately 19,000 people working in the space technology industries in the UK, including the global telecommunications industry. Satellites are key to global positioning systems to aid navigation for shipping and road transport. The industry recruits graduates and technicians from degree subjects such as ***space technology, aeronautical and aerospace engineering, avionics and electronics, physics, and maths***

➡ LINK TO CASE STUDY Page 6.15

Learning Routes and Pathways

Key facts for starting STEM group work sessions/presentations

- Apprenticeships are expanding – there is a STEM skills shortage in processing and technician roles
- Apprenticeships which include STEM skills can be found in a diverse range of sectors – visit www.apprenticeships.org.uk
- The new **Diplomas relating to STEM skills** are: Construction & the Built Environment (2008); Engineering (2008); Information & Technology (2008); Business, Administration & Finance (2009); Manufacturing & Product Design (2009); Science (2011)
- A Level subject numbers – dramatic rise in numbers of students taking psychology (e.g. 52,000 entrants in 2007) and sports science/studies over the past 20 years, compared with numbers taking physics (e.g. 27,000 entrants in 2007), chemistry, maths or biological science
- Degree subjects – the number of overall university applicants rose by 12.2% between 2002 and 2007, but STEM subject applicants rose by just 0.08%
- STEM degree subject numbers at a low base (e.g. chemistry 3,545 acceptances in 2008, mechanical engineering 4,181 acceptances in 2008) compared with more popular subjects (e.g. psychology 12,908 acceptances in 2008, sports science 7,694 acceptances in 2008)
- Studying STEM subjects keeps your options open in the STEM area, and for careers in general
- A STEM degree has added value – there is a high demand for STEM graduates in all employment sectors, with 92% of firms wanting people with these skills (CBI Skills Survey 2008)

Future Trends

Key facts for starting STEM group work sessions/presentations

- **Many of the new jobs** which will exist in the twenty–first century will be created in the STEM area
- The CBI (Confederation of British Industry) predicts that by 2014 the UK will need an extra 730,000 people with **STEM qualifications** compared to 2007
- Scientists and engineers are needed to help solve the problems created by increasing population, increasing energy demands, climate change, food production – **young people can help to make a difference** by choosing STEM subjects and careers
- Opting for a STEM route offers the opportunity to be **creatively involved** in the development of technologies such as – mobile phones, satellite navigation systems, digital technology, space technology
- The UK population is aging, with over 65s predicted to increase from 8.5 million in 2000 to 12.3 million by 2025 – this trend will increase demand on the Health Service with the **STEM skills needed by doctors, nurses, and hundreds of different types of jobs across medicine and health**
- To meet the challenge of climate change, **STEM graduates will be needed** to work on ways of reducing carbon emissions such as – carbon capture and storage, nuclear energy, solar energy, second generation biodiesel fuels
- China and India have 36% of the total world population and their economies will increasingly reflect the size of their consumer markets – **there is a great need for people with STEM skills** to continue UK technological advancements and sustain standards of living.
- Qualifications in STEM are increasingly highly valued as a platform for a wide range of careers outside STEM.

Case studies

Name: Carly Smith
Job title: Instrument Mechanic

1. Describe what your work involves.

I work as an instrument mechanic for VT Nuclear Services and am involved in the repair and maintenance of all types of radiological protection instruments on the Sellafield site, including:

- alpha/beta particulate in air monitors
- gamma alarms
- changeroom equipment, eg; hand monitors, IPMs and frisk probes – an IPM is an Installed Personnel Monitor; it monitors the whole body, including hands, feet and head as you are leaving a trace radioactive area
- criticality incident detection and alarm systems (CIDAS)
- portable pressure instruments
- 2000/6000 series electronic cards – these are nuclear data acquisition cards and there are many types.

Some remedial work is completed on site, but when this is not possible, the repair work is done in the workshop, where repairs are carried out on electronic circuit boards down to component level. I work in both areas.

2. Why did you choose this type of work?

Living in West Cumbria, which is renowned for its strong links with the nuclear industry, I have always thought the Sellafield site would be an interesting place to work. I had thought about a career in the industry, but wasn't sure about how to get a 'foot in the door'. Whilst studying for my A Levels, I became aware of an Apprenticeship programme where you go through college and receive a recognised qualification in your field, but you also learn on the job. I thought this would be invaluable training. Instrument mechanics at Sellafield are in demand so I thought it would be good to develop skills in this area as there will always be the opportunity to work and make a good career.

3. How did you get started?

I applied to a local training provider called Gen II to start an Apprenticeship. I had to pass an aptitude test and interview process to get on to the NVQ Level 2 in Electrical and Instrument Engineering. Once I completed the first year of the Apprenticeship, I was interviewed by the Central Instrument Services (CIS) manager at Sellafield and was then taken on as an apprentice by VT Nuclear Services. After two-and-a-half years I completed an NVQ Level 3 in Instrumentation and the full Apprenticeship. I have now been a full instrument mechanic for two years and I am currently in the second year of study for a Degree in Electrical/Electronic Engineering.

4. What is the importance of maths or science in your work?

Both these subjects are of great importance in my work; the science to get an understanding of the basics of nucleonics and how the instruments work, and the maths to work out electrical/electronic equations, also for everyday tasks such as working out efficiencies.

5. What subjects did you study at school?

I studied the required subjects of maths, English and science, however the choices I took do not reflect the job I do now. These were PE, English language and home economics. I did these subjects at both GCSE and A Level.

6. What qualifications do you need for your job?

You need good GCSEs, especially in maths and science, as these help give a good understanding of the job.

7. What could you earn?

It depends on how far I want to go in my career. At the moment I earn a good salary and this is at instrument mechanic level. It can go up dramatically depending on which path I follow, maybe up to £50,000 a year.

8. What excites you most about your work?

I think one of the most exciting things is the fact that the Sellafield site relies on us to maintain the smooth operations of the plant. If we are not reliable in our job and do not provide the services we are meant to, it has a direct impact on the work force who are obviously unable to go into the active area and carry out their duties. This is a great motivation for getting the job done as efficiently as possible for our customers.

9. What tips could you give to someone who wants to enter this type of work?

I think anyone who wants to enter this field of work should definitely consider looking into an Apprenticeship scheme. Not only do you get the hands-on work, but you also get college training and work towards a qualification such as an ONC or HNC in Electrical, Electronic or Instrumentation Engineering. There is also the possibility to take this further, such as to degree level. If you have ambition, drive and a strong work ethic, then you won't go far wrong in this industry.

10. How do you see the future for your area of work?

The future for engineering in the nuclear industry is bright. It looks like there will be further growth not just in West Cumbria but in other parts of the country as well, as the government has given the nuclear industry the green light for future development. This industry has a strong economic future. This is great news for my area of work because there will always be a need for the services we provide.

Case studies

Name: Catherine Loynd
Job title: Sales Support Engineer

1. Describe what your work involves.

REpower Systems manufactures, installs and services wind turbines. REpower UK is responsible for selling REpower wind turbines within the UK, then project managing the installation of them and providing maintenance services.

I work within the sales department, offering technical support during the sales phase. A large part of my role involves analysing the wind conditions at potential sites. When one of our clients designs a new wind farm site they will install measuring equipment on the site that will measure the wind speed, direction and other parameters over a period of time. This enables our clients to calculate, amongst other things, the energy production that they can expect from the site. This in turn allows them to estimate how much money they will make from the site. I also analyse this data to check that our machines will be suitable for the site and advise clients which of our range of turbines would be best for their site. For example, we have different turbines designed to operate at different average wind speeds. For me, this work involves visiting the site, using computer packages to analyse the data and writing reports.

Other aspects of my role include supporting the sales managers during technical contract discussions and negotiations, and answering technical queries from clients and interested parties. This involves a lot of contact with people, both face to face and via phone/email.

2. Why did you choose this type of work?

I went to the University of Nottingham and studied a Masters Degree in Mechanical Engineering. At university I researched the career opportunities for engineers, and, although I knew I wanted to work in engineering, I graduated without a clear idea of the sector I wanted to work in.

Having gone straight from school to university, I decided to take some time out. I spent a summer surfing in Europe and a winter snowboarding and working in Canada. It was partly during this time that I made the decision to work in the renewable energy sector. I have always enjoyed outdoor activities and the thought that my work would be helping to protect the environment was very motivating.

3. How did you get started?

Having made this decision, I started looking for jobs in the renewables sector. My first job was with Proven Energy (a manufacturer of small wind turbines) and the University of Strathclyde. My role was that of research and development engineer. My work concentrated on the design of the wind turbine blades and research into new materials and methods of manufacture. During my time in this role, I registered for a research degree with Strathclyde and gained an MPhil in Mechanical Engineering. Whilst I enjoyed the work at Proven, when looking for my next job I decided that I would like a role with more interaction with customers or suppliers; a role that would still be technical (although maybe less so) but that would allow me to get out and about a bit more. And that is what I found with my role at REpower.

4. What is the importance of maths or science in your work?

Maths and science have played a very important role in both of my jobs so far. My first role was very technical and involved lots of calculations and practical experiments and research. Even though my current role is less technical, the wind analysis work involves some quite detailed calculations and I have to be able to understand various technical ideas and concepts. It is also important that I understand the operation of the turbines in order that I can explain this to clients or other relevant parties and this requires an understanding of the engineering (including maths AND science) behind them.

5. What subjects did you study at school?

Amongst others, I studied GCSEs in maths, science and technology. At A Level I studied maths, physics, chemistry and Spanish.

6. What qualifications do you need for your job?

You need a degree in engineering or other science/technology subject or equivalent relevant experience in the field of engineering.

7. What excites you most about your work?

I am still excited and motivated by the fact that the work I do has a direct benefit for the environment and the world we live in. However, I have come to realise that the renewables sector offers much more than that. The sector is growing rapidly and will continue to do so as the requirement for installation of renewables continues to increase. Because of this the whole sector is a very exciting place to work and is attracting highly skilled people from other sectors as well.

8. What tips could you give to someone who wants to enter this type of work?

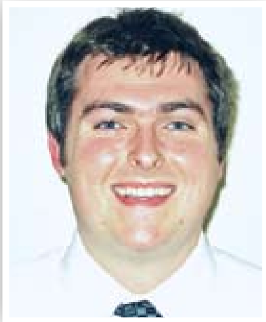
Whilst the renewable energy sector is growing and there are many jobs available, competition is still high. Relevant work experience in an engineering field is invaluable for new graduates and this could be through a sandwich course, summer placement or part-time job. A keen interest in renewable energy and the environment is also beneficial. It can help you stand out from the crowd if you can demonstrate that you have developed other skills, for example the ability to work in teams or good communication, through activities outside of work and study, such as music or sport.

9. How do you see the future for your area of work?

The future of the renewable energy industry is very exciting. The sector will continue to grow by building and improving on existing technologies, such as wind turbines, and establishing and developing new technologies, such as wave and tidal power. A career in the industry will provide an exciting and challenging place to work for the foreseeable future.

Looking to the future I still see a wide variety of options ahead for me. Within REpower, if I wanted to move on, I could perhaps work in one of our international subsidiaries or work in a different role. Most of our sales and project managers are engineering or science graduates. Engineering is still offering me a challenging role and wide variety of future opportunities.

Case studies



Name: Richard Boyle
Job title: Biomedical Engineer

1. Describe what your work involves.

My current work at the University of Strathclyde is the development of an electronic stethoscope system that will allow doctors to hear heart problems more easily. This involves working with electronic circuits and software with the Department of Electronic and Electrical Engineering, and also biological aspects through the Department of Bioengineering. As part of my work I liaise with doctors and representatives from medical device companies. I am also hoping to start up a small business selling stethoscope systems to doctors thanks to funding from Scottish Enterprise through the Royal Society of Edinburgh. So the work is extremely varied and very rewarding.

2. Why did you choose this type of work?

I have always been interested in electronic devices and how they work, and I enjoy applying electronics in order to solve problems and do useful things. I am hoping that I will be able to develop devices and products that will help to improve people's lives.

3. How did you get started?

After school, I did a Masters Degree in Electronic and Electrical Engineering at the University of Strathclyde. I also completed some business classes during my degree course, which initially got me thinking about starting up my own business. I then went on to study an Engineering Doctorate in Medical Devices through which I started the electronic stethoscope project and also had more classes on business-related aspects. I have always been fascinated by biology, and studied classes involving physiology and anatomy which were really interesting and very useful for the work I currently do.

4. What is the importance of maths or science in your work?

Maths and science are extremely important in my work as I use many mathematical techniques in order to analyse the heart sound signals. These techniques are used to reduce the amount of noise that is heard within the heart sounds themselves, and also to enhance the abnormal sounds in order to provide the user with an improved diagnosis of any heart problems.

5. What subjects did you study at school?

I completed six Scottish Highers including physics, maths and English and two A Levels in physics and maths, which were essential in allowing me to get an offer of a place on the degree course.

6. What qualifications do you need for your job?

You need a Masters Degree in Electronic or Electrical Engineering or equivalent.

7. What could you earn?

Potentially I could earn two to three times the average wage.

8. What excites you most about your work?

I am excited by the opportunity to work on exciting, technical projects that could potentially help doctors to diagnose heart problems more effectively and help people live longer and enjoy healthier lives.

9. What tips could you give to someone who wants to enter this type of work?

I would suggest studying hard and selecting maths and physics as well as choosing other subjects that you are really interested in and passionate about.

10. How do you see the future for your area of work?

Unfortunately heart disease is still a huge problem, especially in this country, so there are lots of opportunities in this area of work and any technical developments would be extremely useful.

Case studies

Name: Andrew Rees
Job title: Research Engineer in Micro/Nano Engineering

1. Describe what your work involves.

I work as a research engineer in the field of micro/nano engineering at Cardiff University. Basically, my job requires me to develop processes that can be used to produce components that are below 1mm in size. This can include parts for things such as medical devices, mobile phones, micro gears, printers and digital cameras.

2. Why did you choose this type of work?

I wanted to be involved in state of the art research and development. Working in the field that I do, allows me to work daily on some of the most sophisticated and complex machinery available in the world. Also some of the research that I get involved in combines skills from many different disciplines such as physics, chemistry and computer science. The combination of different disciplines ensures that I'm learning new skills constantly.

3. How did you get started?

I left school at 16 to do an Apprenticeship as a toolmaker for four years. My Apprenticeship allowed me to gain a strong set of practical skills, but it was always my aim to do an engineering degree. During my Apprenticeship I wanted to support the practical skills with some theory and so I studied on a day-release basis to gain an ONC, HNC and HND. Following my Apprenticeship I continued studying and did a degree on a part-time day release basis whilst working as a toolmaker. I gained a Degree in Mechanical and Manufacturing Engineering. Once I completed my degree I found myself in the fairly unique position of having a very strong theoretical background to complement my practical skills. Usually to work in a university you need a PhD, however, because of the unique skill set that I have I was employed without one. However, this was only on the basis that I enrolled on a part-time PhD programme. I am on the verge of completing my PhD in Micro-Electrical Discharge Engineering.

4. What is the importance of maths or science in your work?

To work in engineering research and development, a strong knowledge and understanding of maths and science is essential. You need to understand the physical, biological or chemical behaviour of processes to develop components.

5. What subjects did you study at school?

I studied GCSEs in physics, chemistry, biology, maths, and design and technology, among others.

6. What qualifications do you need for your job?

To do research work at university you usually need a PhD. However, in industry a good degree in physics or an engineering discipline is usually sufficient.

7. What could you earn?

In my present role my salary can reach £44,000 a year.

8. What excites you most about your work?

I think that the work that I'm involved in is helping to develop the way we live. It can include developing components that make our mobile phones do smarter functions or take better photos. One project that I was involved in looked at trying to help a patient with a spinal injury regain the use of their limbs. The area of micro/nano engineering can be used in such a variety of applications that it's become a very interesting field to work in, and one which is constantly developing.

9. What tips could you give to someone who wants to enter this type of work?

The field of engineering research and development can be difficult to break into. However, the job offers many rewards both financially and through job satisfaction. Work hard during your education and this will ensure that a variety of career paths will be open to you.

10. How do you see the future for your area of work?

The area of micro/nano engineering is growing in profile as its application is so varied. Hopefully, due to increasing demanding consumer requirements and government funding this hot research area is going to expand rapidly and keep pushing the boundaries of product and process minimisation.

Case studies

Name: Chris Davis
Job title: Senior Designer

1. Describe what your work involves.

As a senior designer at UK Haptics I work with advanced 3D visual effects and animation software, building 3D models of limbs, bones, muscles, organs, medical instruments, etc. I also create photo-real animations and stills for promotional material. The virtual reality software that we develop is used to help train medical students and nurses in 3D virtual environments.

2. Why did you choose this type of work?

I have been interested in visual effects and computer animation for a long time now, and this way I get to work with some amazing technology and high-end software, where the only real limit in what can be created is your imagination. Working in this specific field is also rewarding in the fact that you're working with a product that has the potential to improve the lives of so many people.

3. How did you get started?

I did a placement with UK Haptics after completing my degree, and before starting my Masters degree at Teesside University. I found the placement through a company that specialises in getting students and recent graduates into the digital industry.

4. What is the importance of maths or science in your work?

Essential. I don't personally have to use maths at an advanced level, being more of an artist/designer, but the software I use has been built by some of the brightest mathematicians and scientists around. The software gives me the tools to create pretty much anything I require, from fluid dynamics, to physics simulations and photo-realistic lighting and surfaces.

Having a good grasp of maths and science is very useful in the industry I work in, but more importantly, if it wasn't for the scientists and mathematicians creating these tools and hardware, the films, games and digital technology that we have today couldn't exist. So the two disciplines work hand in hand really.

5. What subjects did you study at school?

I studied GCSEs including science, maths and English, plus art and design, and went on to study art, design and communications, and computing at A Level.

6. What qualifications do you need for your job?

I did a Degree in Creative Visualisation at Teesside University, followed by a Masters Degree in Creative Multimedia, but there is a greater range of courses around now than when I went to university. Ideally you would have a degree in a field like computer animation or visual effects, or a training course specialising in the digital effects and animation industry.

7. What could you earn?

I think that depends on the company you work for and how far you progress with your skills. Most games companies tend to be fairly huge, so it's a little harder to move up the ranks, but you can earn a substantial salary if you really progress in your field of work. I often spend chunks of my own time trying out new ideas or learning new things. If your employer sees the effort you put in and your passion, your salary will reflect that.

8. What excites you most about your work?

One of the main things for me is the total creative freedom I have with the tools I use. However, I also have to be very accurate with the models that are made, as they are to be used in medical simulations. I work on some projects where I can really use my imagination, and use all the amazing technology we have here to build and bring to life my own creations. Working with human anatomy is also fascinating for me – the human body is such an amazing organism, and you really get a deeper understanding of how it works when building all the muscles and organs in 3D.

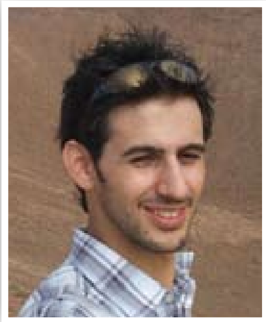
9. What tips could you give to someone who wants to enter this type of work?

Start now! A lot of people think you have to wait until university or college to start learning the necessary software and tools they need, but most home computers can run the software now, and there are personal learning editions to most of the tools you need. A good grounding in all areas of cinematography and art is also useful, as is some knowledge of cameras, lighting and the way light and colour work. Joining a forum is also a good idea.

10. How do you see the future for your area of work?

I think the process of turning ideas into reality will speed up dramatically as the power of hardware and tools increases. Real-time technologies will be implemented more, meaning less time having to wait for renders or animations to process, and more time to actually create and animate. 3D is also starting to take off. Television, games and films will increasingly be viewed in stereo 3D. I can see touch screen technology and Haptic devices becoming part of home computers. With the success and ease of use of devices such as the iPhone and Wacom tablets I think drawing and creating directly on the screen will become the norm.

Case studies



Name: Chris Antoniou
Job title: Mechanical Design Engineer

1. Describe what your work involves.

I am a graduate engineer in my dream job. You'll find some of my best work up in space. Working at Surrey Satellite Technology Ltd (SSTL), world leaders in the design and manufacture of small satellites, I am a member of the team responsible for the design, manufacture and testing of spacecraft structures.

These structures must withstand harsh G-forces encountered during launch, and continuous hot-to-cold temperature variations during their orbit around the Earth. Therefore, all the spacecraft we design go through a rigorous testing regime, initially simulated with computer software, and then onto real-world testing. I am also involved in the design of subsystems, such as solar panels, control mechanisms and sensors.

Most of my work is carried out using CAD software, but you may also find me in the assembly room constructing an SSTL spacecraft, or in our specialist vibration testing facilities, shaking a structure to pieces – or rather trying to!

2. Why did you choose this type of work?

I have been interested in mechanics and solving mechanical problems from an early age, initially building, designing and racing radio-controlled cars and planes. Today my hobbyhorse is bicycle and motorbike mechanics, so it makes sense that my dream job takes my mechanical problem-solving skills to a new level.

Problem solving for me at SSTL means designing and building spacecraft equipped for the environment of space, ensuring lifetimes that cover the job they are there to do, within customers' budgets. As a design engineer, I am involved in all aspects of the spacecraft lifecycle – from designing the initial structure, through to manufacture, assembly and eventually testing my own solutions – once nothing more than an idea or a sketch in a notebook.

3. How did you get started?

I helped a friend to design a spacecraft at university and realised just how interesting the space industry was. So when an opportunity to work for SSTL came up, I took it.

4. What is the importance of maths or science in your work?

Most of my work is based on a fundamental understanding of maths and materials science. Materials science is used to understand why our satellites may fail during launch or up in space. For example, the structural material may weaken from the continuous expansion and contraction caused by the temperature fluctuations in a space environment.

5. What subjects did you study at school?

Among others, for GCSE I did maths, physics, chemistry and biology and for A Level I did maths and statistics, physics, and design and technology.

6. What qualifications do you need for your job?

I have a Degree in Mechanical Engineering. Generally to enter this field you need a good degree in a relevant subject, such as mechanical or aerospace engineering.

7. What excites you most about your work?

What most excites me is having the opportunity to work on complex designs which will be shot off into space.

8. What tips could you give to someone who wants to enter this type of work?

My advice to anyone wishing to enter this field, beyond obtaining a good university degree, is also to prove your passion for the subject to help you stand out from the crowd. For example, enter competitions or develop mechanics-type hobbies. If you can't find such opportunities, then make your own. Build or design something – that's what I did. You will be rewarded for your efforts with a good starting salary, increasing quickly as you gain more experience and skills.

9. How do you see the future for your area of work?

The future for the satellite business is good. It can only continue to grow as we continue to explore and exploit space further. New applications for our small satellites are cropping up all the time – satellite navigation and monitoring systems for agriculture, natural disasters, traffic and pollution. We also send science experiments into space, so that will be a continuing source of interest.

ACTIVITY 1

STEM day

An introductory, awareness raising activity to highlight the range and diversity of STEM jobs and their impact on our daily lives.

Summary

Students consider the range of STEM jobs that have affected and continue to affect the way they live.

Materials

Resources as provided or indicated on resources pages – *diary page worksheets, jobs list, large sheets of card or flipchart paper (enough for one per small group), flipchart pens.*

Careers information directories and/or access to computers

Preparation

Print or photocopy and cut out the various cards and worksheets to be used.

Steps

1. Class work in small groups

Explain that they are going to think about their daily life, what they do, where they live, where they go etc. and consider where and how STEM jobs or subjects have been involved. Some activities will be obvious, listening to their iPod, using their computers, doctor's appointment, for example. Encourage them to consider less obvious activities. Suggest that they start at the beginning of a day and work through. Talk them through some examples:

Getting out of bed

- the bed and bedding – for example textile development and testing, the mattress will have been designed and tested for maximum support and durability

Washing and dressing

- running water, hot water, soap – engineering, research scientists, plumbing
- clothes – textile development, machine design and development…

Eating breakfast

- Cereal – product development, soil analysis, environmentalists, food processing…

Give each group a diary page worksheet and allocate different days or parts of a day and weekends for them to work through, e.g. weekday school morning, weekday school afternoon and evening, Saturday, Sunday, weekday in the school holidays. Ask them to discuss their day and complete the 'diary' together.

Some of the following suggestions may help if they appear to be stuck:

- playing football (or any other sport)
- watching TV
- shopping
- disco
- paper round (or other part–time job)
- lessons
- hairdressers…

2. Once groups have several ideas listed, take feedback and continue discussion

- Ask each group to explain one of the activities they have identified and its possible STEM links.
- Have they been surprised by any of their 'findings'? If so, in what way?
- Discuss with them what subjects they think would be needed, or help for the areas of work identified so far.
- Encourage them to work towards the conclusion that STEM subjects can lead to a wide range of jobs.

3. Ask students, in their groups, to consider their favourite activity, e.g. computer games, eating chocolate. Tell them to discuss and select one activity/item for their group.

- Give each group a large sheet of card or flipchart paper and some pens. Explain that this time they are going to identify specific job titles connected to their choice and produce a poster to illustrate this.
- Give them the list of jobs and ask them to write on their flipchart those that they think would or could be involved.
- Be prepared to answer questions about what some of the jobs are or have a selection of resources to hand out for students to use.
- If computers are available to them they could research jobs and use them to produce their posters. Set an appropriate time limit.
- If they can access the website www.futuremorph.org it provides interesting information for them.
- Once posters are complete ask each group in turn to display their poster and talk through what they have included and why. Other groups can contribute other suggestions.
- It may be possible to display the posters in a careers/Connexions resource centre.

STEM diary

Day

Activity	STEM impact

ACTIVITY 2

STEM speed dating

An introductory, awareness raising activity to highlight the diversity and importance of STEM, associated careers and the speed of developments in the field.

Summary

Students use cards to consider timings of a selection of events, discoveries and developments and place them in the appropriate decade on a timeline.

Materials

Resources as provided or indicated on the resources pages 6.24 – STEM cards, decade cards, 'local/us' cards, blank cards

- reusable adhesive, large flipchart sheet or paper.

Preparation

- Print or photocopy and cut out the various cards to be used. It may be useful to use card or laminate them if planning to use this activity more than once.
- Prepare the flipchart paper as indicated on the resources pages.
- Place/stick the 'decade' cards along a wall, leaving enough room for a group of students to stand by each one, and put some reusable adhesive next to each card.
- Place the flipchart/large paper in the front of the room.

Steps

1. Give each student one of the 'local/us' cards

- Ask them to read it and think about the decade in which it happened. (Depending on the numbers in the session, groups of four/five students should have identical cards.) Explain that the decades chosen cover the lifetime of people they may know or know about.
- For those with the 'I started secondary school' it will be easy. Some help may be needed for students having cards with other generations of family on. Explain that they don't need to be exact and personal information isn't needed – just an idea of the likely decade.
- Ask students to take their cards and stand next to the decade they think is appropriate.
- Briefly discuss what they have placed in each decade. Explain that the purpose of this is to give them an awareness of the time/timing for the timeline they are going to work towards.
- Tell them to move to the flipchart and, using some reusable adhesive, stick their cards in the appropriate place in the top row.

2. Class work in small groups (the groups could be those that formed around each decade)

- Give each group the set of cards for one area (health, education etc.) Explain that these are just a selection of events/discoveries from the decades they have considered earlier.
- Ask the groups to discuss and decide which they think is the correct decade for each of their cards.
- When they have agreed they stick their cards on the flipchart in what they consider is the appropriate decade.
- When all cards are on the flipchart ensure that all students can see it and begin to talk them through the answers and discuss/question which one(s) are correct and which ones they think need moving. Each group, in turn, could indicate which they think happened first in their area.
- Question them as to what surprised them and why. Remind them that this is only a selection of developments during this period.
- If they have not previously been aware of STEM ask them what all the cards have in common.
- The answer – STEM (science, technology, engineering, maths). All the developments relate in some way to these subjects.

Continue the discussion to include:

- What they think have been the most important developments.
- Has the speed of development been faster or slower than they would expect?

3. Back in their groups ask them to look at the timeline they have produced and think about what developments they would like to see in future decades

- Give them blank cards and ask each group to write one development they would like to see with an estimated date. They place these cards at the far right hand end of the flipchart.

4. Discuss with them what careers/jobs they think would be needed to achieve the developments they have suggested

- What subjects/courses would help?
- List these on paper for future sessions.

ACTIVITY 3

STEM speed dating (alternative)

An introductory, awareness raising activity to highlight the diversity and importance of STEM, associated careers and the speed of developments in the field.

Summary

- Students use cards to consider timings of a selection of events, discoveries and developments and place them in the appropriate decade on a timeline.
- A 'Bingo' style game is used to help identify decades.

Materials

- Resources as provided or indicated on resources pages
- STEM cards (you will need to have six from each decade covering each of the areas, health, entertainment etc)
- Decade cards – one for each group
- 'Local/us' cards, World/International cards, blank cards
- Reusable adhesive, large flipchart sheet or paper.

Preparation

- Print or photocopy and cut out the various cards to be used.
- A selection of STEM cards for each area is given for you to select from as appropriate. The Decade cards have only six boxes to be filled as the game and discussion can take a long time to complete with more.
- It may be useful to use card or laminate them if planning to use this activity more than once.
- Prepare the flipchart paper as indicated on the resources pages.
- Place the flipchart/large paper in the front of the room.

Steps

1. Give each student one of the 'local/us' cards

- Ask them to read it and think about the decade in which it happened. (Depending on the numbers in the session groups of four/five students should have identical cards.) Explain that the decades chosen cover the lifetime of people they may know or know about.
- For those with the 'I started secondary school' it will be easy. Some help may be needed for students having cards with other generations of family on. Explain that they don't need to be exact and personal information isn't needed – just an idea of the likely decade.
- Discuss with students what they think are the appropriate decades. When agreement has been reached tell them to move to the flipchart and, using some reusable adhesive, stick their cards in the appropriate place in the top row.

Explain that the purpose of this is to give them an awareness of the time/timing for the timeline they are going to work towards.

Place the World/International cards on the bottom row to give them an idea of some world events before moving on to using the STEM cards.

2. With class working in six small groups, give each group a Decade card to use as a 'Bingo' card.

- Explain that you are going to read out a selection of events/discoveries from the decades they have considered earlier. They will need to decide whether or not it belongs to their decade.
- Read out a STEM card and ask which group wants to 'claim' it.

You can adjust the rules/method of play depending on your group, for example:

- Give the card to the first group to call out, irrespective of whether or not it is correct, and as the game goes on and students realise some answers are incorrect they can negotiate with others and discuss why they thought what they did.
- Only give the card to the group with the correct decade if they claim it and save unclaimed and incorrectly claimed cards for negotiating at the end.
- For a visual timeline once all the decade cards are completed and correct students can place their STEM cards on the flipchart/paper in what they think is the appropriate area (health, entertainment, etc.) Some discussion may be needed at this point and an acknowledgement that some cards can be allocated to more than one area.

3. When all cards are on the flipchart ensure that all students can see it and question them as to what surprised them and why.

- Remind them that this is only a selection of developments during this period.
- If they have not previously been aware of STEM ask them what all the cards have in common.
- The answer – STEM (science, technology, engineering, maths). All the developments relate in some way to these subjects.

Continue the discussion to include:

- What they think have been the most important developments
- Has the speed of development been faster or slower than they would expect?
- What they think motivates development…etc

4. Back in their groups ask them to look at the timeline on the flipchart and think about what developments they would like to see in future decades.

- Give them blank cards and ask each group to write one development they would like to see with an estimated time. They place these cards at the far right hand end of the flipchart.

5. Discuss with them what careers/jobs/ they think would be needed to achieve the developments they have suggested.

- What subjects/courses would help?
- List these on paper for future sessions.

Resources

Large flipchart sheet or paper prepared as follows

	50s	60s	70s	80s	90s	00s	Future
local/us							
health							
nature, environment							
education, IT, communication							
entertainment, culture							
industry, business							
international							

DECADE cards

50s

60s

DECADE cards

70s

80s

DECADE cards

90s

00s

‘Local/us’ cards

You will need 5/6 of each of these to enable students to form groups.
You may want to change/add others as appropriate for your students.

I started secondary school	My parents’ generation started secondary school	My grandparents’ generation started secondary school
I started secondary school	My parents’ generation started secondary school	My grandparents’ generation started secondary school
I started secondary school	My parents’ generation started secondary school	My grandparents’ generation started secondary school
I started secondary school	My parents’ generation started secondary school	My grandparents’ generation started secondary school
I started secondary school	My parents’ generation started secondary school	My grandparents’ generation started secondary school
I started secondary school	My parents’ generation started secondary school	My grandparents’ generation started secondary school

'Local/us' cards

You will need 5/6 of each of these to enable students to form groups.
You may want to change/add others as appropriate for your students.

Hollyoaks started	First Harry Potter book	Elizabeth II became Queen
Hollyoaks started	First Harry Potter book	Elizabeth II became Queen
Hollyoaks started	First Harry Potter book	Elizabeth II became Queen
Hollyoaks started	First Harry Potter book	Elizabeth II became Queen
Hollyoaks started	First Harry Potter book	Elizabeth II became Queen
Hollyoaks started	First Harry Potter book	Elizabeth II became Queen

‘Local/us’ cards

You will need 5/6 of each of these to enable students to form groups.
You may want to change/add others as appropriate for your students.

First Doctor Who programme televised	Our school was built	Diana, Princess of Wales, died
First Doctor Who programme televised	Our school was built	Diana, Princess of Wales, died
First Doctor Who programme televised	Our school was built	Diana, Princess of Wales, died
First Doctor Who programme televised	Our school was built	Diana, Princess of Wales, died
First Doctor Who programme televised	Our school was built	Diana, Princess of Wales, died
First Doctor Who programme televised	Our school was built	Diana, Princess of Wales, died

STEM cards

Health	Nature/Environment	Education/IT/Communication
Rosalind Franklin discovers the helical shape of RNA/DNA nucleic acids	The idea of solar wind is put forward by Eugene Parker	Texas instruments devise and market the first hand held calculator
Lasers first used in surgery	Apollo 8 is first manned spacecraft to orbit the Moon	First email message sent
First female contraceptive pill is developed	Helen Sharman becomes the first Briton in Space	Release by IBM of first personal computer complete with Microsoft operating system
Materials scientists develop synthetic skin	First world climate conference	Silicon chips used for the first time in computer memory applications
Invention of disposable contact lenses	Nuclear power becomes the primary energy source in Arco Idaho in the US	Tim Berners-Lee invents the World Wide Web
Fibre optic endoscope is tested on human patient	Satellite observation of Hurricane Andrew enabled thousands of people to evacuate threatened Florida areas	First transatlantic telephone cables
Polymer water implants used to treat brain cancer	General Motors introduces the catalytic converter	First portable cell phone call made
First oral polio vaccine developed	TIROS-1 is the first meteorological satellite to be launched	First use of the computer mouse to demonstrate how text files could be clipped, copied and pasted
Three blind patients receive the world's first bionic eyes comprising 3,500 microscopic solar cells which act to convert light into electrical impulses	Revelle and Keeling announce potential problem of greenhouse gas emissions and begin a study of the levels of carbon dioxide in the atmosphere	Formation of Microsoft computer software company by Bill Gates and Paul Allen
Human genome project finishes with complete mapping of human DNA sequences	World's first commercial wave power station opens in Scotland	CD-ROM devices introduced into computers

STEM cards

Entertainment/Culture	Industry/Business/Finance	International
First video game invented by Ralph Bauer	Bar codes scanned using lasers are placed on shopping products for the first time	England's pupils placed in top 10 for science and maths in global league table
Colour television pictures are first transmitted	First non-stick pans developed using Teflon	Modern high explosives developed for the first time
Fuji develop and market the first disposable camera for photography	Launch of first small scale photocopying machine	Minister announces more 'flash and bang' needed to enthuse pupils in school science as a 21% drop in positive attitudes is recorded
Kodak launched the instant colour camera	Volkswagen began testing photovoltaic arrays mounted on roofs of vehicles to tap solar energy	Kyoto Protocol on reduction of carbon dioxide emissions agreed
First digital TV channels available in the UK	General Motors introduces the catalytic converter	Control of Pollution Act passed in the UK, exerting tighter controls on industrial pollution
ITV launched in the UK	Synchotron light source becomes operational producing X-rays for structural analysis	UN Conference on Solar Energy in the Developing World
Apple's iPhone goes on sale with features including touch screen, media player, wi-fi, camera and web-browser	Development of Scotchguard fabric and material protector by Patsy Sherman	Research suggests supply of large fish in the seas has diminished by 90% since 1950
Stereo FM radio broadcast for the first time	To improve vehicle safety, Pontiac develops bumpers that partially absorb the energy of a collision	Friends of the Earth formed
Invention of synthetic alternative to grass – Astroturf. Introduced into American sports stadia and patented	Concorde the first commercial supersonic aircraft is launched to the public	Devastating tsunami generated by an earthquake of magnitude 9.0 claims 300,000 lives across Indonesia, Thailand and India
First Digital Versatile Disc (DVD) players launched in Japan	Kurt Ziegler and Giulio Natta awarded Nobel Prize for their work on the chemistry of high polymers	Alliance of Small Island States demand a 20% reduction in global emissions by 2005 fearing they might disappear under rising sea-levels
First computer game devised Spacewar	Launch of two biodegradable plastics	World population surpasses 6 billion

STEM cards with answers

Health	Nature/Environment	Education/IT/Communication
Rosalind Franklin discovers the helical shape of RNA/DNA nucleic acids. (1951)	Nuclear power becomes the primary energy source in Arco Idaho in the US. (1955)	First transatlantic telephone cables. (1956)
First female contraceptive pill is developed (1954)	Revelle and Keeling announce potential problem of greenhouse gas emissions and begin a study of the levels of carbon dioxide in the atmosphere. (1957)	Texas instruments devise and market the first hand held calculator (1967)
Fibre optic endoscope is tested on human patient. (1957)	The idea of solar wind is put forward by Eugene Parker. (1958)	First use of the computer mouse to demonstrate how text files could be clipped, copied and pasted. (1968)
First oral polio vaccine developed. (1962)	TIROS–1 is the first meteorological satellite to be launched. (1960)	Silicon chips used for the first time in computer memory applications. (1970)
Lasers first used in surgery. (1985)	Apollo 8 is first manned spacecraft to orbit the Moon. (1968)	First email message sent. (1972)
Materials scientists develop synthetic skin. (1986)	General Motors introduces the catalytic converter. (1974)	First portable cell phone call made. (1973)
Invention of disposable contact lenses. (1987)	First world climate conference. (1979)	Formation of Microsoft computer software company by Bill Gates and Paul Allen. (1975)
Polymer water implants used to treat brain cancer. (1996)	Helen Sharman becomes the first Briton in Space. (1991)	Release by IBM of first personal computer complete with Microsoft operating system. (1981)
Three blind patients receive the world's first bionic eyes comprising 3,500 microscopic solar cells which act to convert light into electrical impulses. (2000)	Satellite observation of Hurricane Andrew enabled thousands of people to evacuate threatened Florida areas. (1992)	CD–ROM devices introduced into computers. (1987)
Human genome project finishes with complete mapping of human DNA sequences. (2000)	World's first commercial wave power station opens in Scotland. (2000)	Tim Berners–Lee invents the World Wide Web. (1989)

STEM cards with answers

Entertainment/Culture	Industry/Business/Finance	International
Colour television pictures are first transmitted. (1951)	First non-stick pans developed using Teflon. (1954)	Modern high explosives developed for the first time. (1955)
ITV launched in the UK. (1955)	Development of Scotchguard fabric and material protector by Patsy Sherman. (1956)	UN Conference on Solar Energy in the Developing World. (1961)
Stereo FM radio broadcast for the first time. (1961)	Launch of first small scale photocopying machine. (1958)	Friends of the Earth formed. (1969)
First computer game devised Spacewar. (1962)	Kurt Ziegler and Giulio Natta awarded Nobel Prize for their work on the chemistry of high polymers. (1963)	Control of Pollution Act passed in the UK, exerting tighter controls on industrial pollution. (1990)
First video game invented by Ralph Bauer. (1967)	To improve vehicle safety, Pontiac develops bumpers that partially absorb the energy of a collision. (1967)	Alliance of Small Island States demand a 20% reduction in global emissions by 2005 fearing they might disappear under rising sea-levels. (1994)
Invention of synthetic alternative to grass – Astroturf. Introduced into American sports stadia and patented. (1967)	Bar codes scanned using lasers are placed on shopping products for the first time. (1974)	Kyoto Protocol on reduction of carbon dioxide emissions agreed. (1997)
Kodak launched the instant colour camera. (1972)	General Motors introduces the catalytic converter. (1974)	World population surpasses 6 billion. (1999)
Fuji develop and market the first disposable camera for photography. (1986)	Concorde the first commercial supersonic aircraft is launched to the public. (1976)	Research suggests supply of large fish in the seas has diminished by 90% since 1950. (2003)
First Digital Versatile Disc (DVD) players launched in Japan. (1996)	Synchotron light source becomes operational producing X-rays for structural analysis. (1981)	Devastating tsunami generated by an earthquake of magnitude 9.0 claims 300,000 lives across Indonesia, Thailand and India. (2004)
First digital TV channels available in the UK. (1998)	Volkswagen began testing photovoltaic arrays mounted on roofs of vehicles to tap solar energy. (1982)	England's pupils placed in top 10 for science and maths in global league table. (2008)
Apple's iPhone goes on sale with features including touch screen, media player, wi-fi, camera and web-browser (2007)	Launch of two biodegradable plastics. (1990)	Minister announces more 'flash and bang' needed to enthuse pupils in school science as a 21% drop in positive attitudes is recorded. (2008)

7 Industry Focus

Spotlight on key STEM industries, including case studies

The UK Space Industry

Introduction

Ask most people about the UK Space Industry, and the most common responses are either 'what space industry?' or 'wasn't that something to do with a Beagle or something'?

The latter statement refers to the UK's Beagle 2 spacecraft, destined to land on Mars on Christmas Day 2003. This mission captured the public's imagination due to several factors; its iconoclastic lead scientist Professor Colin Pillinger, and the mission fundraising links with the musicians Blur and the Lander Operations Control Centre at the National Space Centre in Leicester. This was the first time an active spacecraft mission control centre had ever been visible in real-time to the general public.

When contact was lost with Beagle 2 on Christmas Day 2003 it seemed that the whole nation was caught up in the search effort as scientists tried to pin-point what happened to the brave spacecraft in the final landing phase, after a mission lasting several months covering millions of kilometres of deep space travel to another world. When it became clear that Beagle was lost, it seemed that the general public's awareness of UK space activity all but disappeared.

With no official UK astronauts and manned space programme, unlike Russia, China, several European countries and of course the USA, is it any wonder that the general perception is so ill informed?

The UK Space Industry – our best-kept secret!

In fact the UK Space Industry is one of the fastest growing sectors of the country's economy. Employing nearly 19,000 individuals, in 2006-7 the total turnover was nearly £6 billion and has shown accelerating growth rates over the last five years, from 5% in 2004-5 to nearly 8% between 2006 and 2007. The annual turnover of the worldwide space sector is in excess of $200 billion and is forecast to exceed $1 trillion (thousand billion) within 12 years.

In the UK the space industry is extremely diverse and includes university-based groups such as the University of Leicester's Space Research Centre and UCL's Mullard Space Science Laboratory as well as companies such as Infoterra (supplying much of the information used in services including Google Earth amongst others), Surrey Satellite Technology Limited (SSTL) and Avanti. The trade association for the industry is UKSpace with 22 members and the UK Space Directory lists more than 100 companies actively engaged in utilising space-derived products and services.

The UK has no dedicated 'space agency' along the lines of NASA. The British National Space Centre (BNSC) is a partnership of seven Government Departments, two Research Councils, the Met Office and the Technology Strategy Board. It co-ordinates UK civil space activities and represents the UK at the European Space Agency (ESA). The Director-General reports to the UK Minister for Science and Innovation.

What relevance does space have to our everyday lives?

It has been 51 years since the launch of the world's first artificial satellite, the Soviet Union's Sputnik1, in 1957. Driven by the geopolitical ideological struggle between the systems of communism (USSR) and capitalism (USA) known as the 'Cold War', advancements in technology and applications proceeded at breakneck speed.

Project Apollo succeeded in putting humans on the Moon only eight years after Yuri Gagarin's historic 1961 flight into space. In the half century of the Space Age, nearly 500 humans have orbited the Earth, travelling more than five miles every second as they go round the planet every 90 minutes. Thousands of unmanned satellites have been launched into myriad orbital paths around our home planet. Robot spacecraft have explored most parts of the solar system and the great space observatories such as the Hubble Space Telescope have peered out to the edge of the visible universe and back in time to the dawn of creation, nearly 14 billion years ago.

There is no doubt that the scientific discoveries of the Space Age have transformed our understanding of not only our place in the universe but of our own planet itself. Beyond the science, though, what relevance does space have to our everyday lives in the twenty-first century?

Telecommunications

In 1962, the world's first telecommunications satellite, Telstar 1 was launched. Until then, global TV/radio communication was largely non-existent. In the intervening 46 years the situation has been transformed beyond all recognition. Orbiting the Earth, 22,000 miles above the Equator, is a 'ring system' of more than 300 active telecommunications satellites. It's more than just Sky TV and the World Cup that gets beamed down from these. The majority of global finance transactions and an increasing amount of global internet traffic use this network. This network of telecommunications satellites has led to the phenomenon of the 'global village', one in which political events on one part of the planet can have global consequences within hours.

Such is our dependence on satellite telecommunications that some commentators have calculated that if the satellites were all switched off, the global economy would grind to a halt in less than a day! Inmarsat and Avanti Communications are two UK-based companies that are world leaders in this field.

Earth observation

The data collected by meteorological satellites saves tens of thousands of lives each year. Earth observation satellites have given us unique perspectives on the impact of human activities on the state of the atmosphere, land and oceans as well as insights into potential solutions. Humanity has woken up to the challenges posed by climate change and industrial pollution – many of our key discoveries have been possible only through the use of space-borne observation platforms. Leading UK companies in the Earth observation field include Infoterra and Surrey Satellite Technology Limited (SSTL).

Global Positioning System – it's not just 'SatNav'!

Satellite navigation systems rely on precise time measurements from several 'constellations' of satellites, most notably the US Global Positioning System (GPS). Originally developed for use by the military, the last few years have seen an explosive growth in applications of GPS technology. The UK's leading expert in this field, Professor Terry Moore of the University of Nottingham's Institute of Engineering, Surveying and Space Geodesy (IESSG), predicts that within 15 years applications of GPS technology will be as essential to our everyday lives as the 'world wide web'.

The importance of STEM subjects in this sector

Contrary to stereotype there is no such subject as 'rocket science'. Roles within the space sector range from pure scientific research to geographical, engineering, electronics and chemical applications. A key skill sought by employers is a background in a numerically-based discipline such as electronic engineering, mechanical engineering, physics, chemistry or maths but this list is not exhaustive. The ability to apply a wide range of scientific and mathematical skills to complex projects is what is desired along with general business and communication/ presentation skills.

Case Studies – EADS Astrium Graduate Trainees – Ed Bean and Martin Garland

EADS Astrium is the largest satellite manufacturer in Europe. A wholly-owned subsidiary of EADS, the company that builds the A380 'superjumbo', Astrium has over 12,000 employees across Europe with nearly 3,000 employees based in the UK – mainly at Stevenage, Portsmouth and Poynton.

Specialising in the design of satellites, Astrium is involved with telecommunications satellites, earth observation satellites, navigation and military systems, space telescopes and robot explorers destined for other planets in the solar system.

There are two primary routes into the company for young people:

- *Graduate Development Programme (GDP)*
  The GDP is designed for students who have graduated from university with either a Bachelor's degree or a postgraduate qualification. It is a two-year programme tailored to the needs of the individual. Graduate trainees are given an overview of how the company operates and improve their technical knowledge and skills through real work challenges and projects. There are opportunities to work in various technical disciplines and on other sites, including those outside of the UK. Specialised leadership training is built into the GDP in addition to any necessary technical training to develop the future leaders of the business.

- *Apprenticeship*
  The apprentices employed by Astrium tend to have vocational backgrounds, having joined the company after gaining GCSEs, A Levels or a vocational qualification such as a BTEC. The scheme involves spending a year at college full time, before rotating around different engineering and manufacturing departments for a further two years. Apprentices work towards a Foundation Degree in Electrical and Mechanical Engineering and at the end of the Apprenticeship there is an opportunity to study further on a day release basis for a degree.

Two of Astrium's GDP trainees, Martin Garland and Ed Bean have, as part of their roles, been involved in showcasing Astrium's work on the ExoMars mission to students at the National Space Centre, Leicester. This is part of Astrium's commitment to supporting STEM education initiatives and the company is proactive in seeking solutions to the workforce supply concerns that are manifest in many parts of the UK science industrial sector.

ExoMars is the first European mission to land a rover vehicle on the surface of Mars and forms part of a much larger solar system exploration strategy called Aurora. The UK is the prime contractor for the ExoMars rover which will traverse the Martian terrain searching for signs of water and life.

The ExoMars rover also carries a drill, the first time such a device has been taken to another planet, which will obtain samples from two metres below the surface because scientists think there may be ice or water buried deep in the rock.

The mission is due for launch in 2016.

Interview – Martin Garland

What interest did you have as a child/ teenager in space/science?

From an early age I was into Lego, (age 18 months I owned my first Lego blocks). This progressed on to more complex parts as I got older; I used to make challenges for myself like design a Lego vehicle that could climb stairs.

I've always been good at building things. In Year 7, my Lego skills were applied to radio-controlled model cars, boats and gliders (made from balsa wood). In the same year, I entered a Young Engineer's competition for best invention, where I made a hovering car model and won first prize for my category.

But it wasn't until Year 10/11 that I discovered a flare for computer programming. At this age IT was taught at GCSE and I had just received a Lego Mindstorms kit (robotic Lego) for Christmas. At this time I also received my first telescope and I often used to look at the moon and be inspired.

What A Levels did you do?

Because of genuine interests and strengths in these subject areas my choices were physics, computing, maths and geography.

What degree did you do?

Degree in Design Technology for Robotics at Staffordshire University.

I would highly recommend this course to anyone who likes a hands-on-approach to learning robotics. Unlike many robotics degrees it is one where students get the chance to build robots in their first year, continuing to do so throughout the course.

For my final year project I made an eight-legged walking robot with terrain adaptation (scratch built) and programmed using a PIC chip. Little did I know that the servos used in my model radio-controlled cars and gliders would become the building blocks for my future robotics projects. The project was highly successful and I won an Institution of Engineering and Technology (IET) competition at the end of the year as well as an award for overall best final year project at Staffordshire University (in engineering and technology).

At university I also had the opportunity to become involved with Staffordshire Setpoint where I helped to develop a Lego activity where children could design and program a Lego rover to collect a mars bar. I also had the opportunity to be a technical judge at the UK national FIRST Lego League final 2007, through Setpoint.

When did you become aware of Astrium's scheme – and how did you become aware?

The first time I heard of Astrium was when I attended a graduate recruitment event at the NEC, Birmingham, in my final year of studies. I had just assembled my eight-legged walking robot and had it walking at this point, so I took it to the event. I showed it working to companies to demonstrate my skills, and soon a lot of employers wanted to talk to me.

I was invited by the event organiser, as a VIP guest, to another graduate recruitment event and this was when I first met Astrium. I was drawn to their stand by a large Mars rover model, and spoke to Paul, who I now work with. Up until this point I still was unsure where I wanted to go with my robotics skills, but as soon as I learnt about Astrium and what they do, and what Paul does for his job I knew I had found it.

My application was successful and I was invited to an interview where I took my now finished eight-legged walking robot, demonstrating terrain adaptation, which I believe played a large part in me securing a job at Astrium.

Staffordshire University was so impressed with my robot that they offered to buy it from me so that they can use it for further development and research. Of course I accepted but asked them to pay me in robot parts so that I could not only make a second but also develop one or two other ideas I had.

When at school, were you aware of the UK space industry?

At school I was very aware of NASA, but did not know about companies such as Astrium or Thales. Because of my specific interest in robotics I have only recently been introduced to such companies.

What have you done since being on the scheme in terms of training?

I joined Astrium in September 2008.

- Aside from the initial introduction, Astrium provides personal development training for every graduate that aims to improve personal skills for working in groups and self-confidence.
- A mentor has been assigned to assist me through the graduate programme and will help me to become a chartered engineer.
- Much of the technical work I do is learnt from other experienced employees on the same project. I am learning all the time, how to design systems used in space and current technical limitations.

What are your specific roles on ExoMars and other Astrium projects?

My job title is mechanisms/robotics engineer. I joined Astrium in the Mechanisms Department as a Direct Entry Graduate, meaning that I do not rotate between departments every six months. However, if I wish to spend six months in another department then this can be considered. This was the ideal situation for me as I knew that my area of interest is robotics and that mechanisms at Astrium cover any electro-mechanical systems which often are featured on the more exotic missions like ExoMars.

I have recently been involved with the ExoMars team as a result of my area of expertise. So far I have assisted them with general technical issues and PR events. However, my main activity at work is working on a robotics demonstrator project, which aims eventually to lead to a robotics centre at Astrium. The project is currently at stage 1 where off-the-shelf robotic platforms are being developed for later robotics research for missions like ExoMars, Explora and Mars Sample Return. Each day I have the opportunity to work alongside Bridget*, which will later be incorporated into the research and development activity at Astrium.

(* 'Bridget' is the technology demonstrator and test vehicle for the ExoMars rover mission. A six-wheeled robotic spacecraft designed to operate on the Martian surface, 'Bridget' has two robotic test vehicle siblings, 'Bruno' and 'Bradley'.)

What do you see as your potential career path in the next five years?

I would very much like to stay at Astrium and provided that a robotics department or centre emerges there will be a place I will fit comfortably into. Before 2016, I can see myself working on mechanisms for future projects similar to ExoMars and Mars Sample Return. ESA has recently announced that a robotics space centre will be built near Oxford and no doubt the work I will be involved with at Astrium will mean liaising with this centre, further developing my knowledge and expertise.

Interview – Ed Bean

What interest did you have as a child/teenager in space/science?

I was always interested in the unknown, and space and science caught my imagination! One day, I entered a competition to go to Space Camp in America (just like Challenger Centres). It was great fun, and I decided I'd like to do 'space' as a job.

What A Levels did you do?

German, computing, physics and maths.

What degree did you do?

Degree in Physics with Space Science and Space Technology at the University of Leicester.

When did you become aware of Astrium's scheme – and how did you become aware?

I did summer work experience for Astrium during my summer holidays from university after seeing a presentation on Astrium at a science/space conference.

When at school, were you aware of the UK space industry?

I really first became aware of the UK space industry when I was at college and someone mentioned they'd worked at Astrium Portsmouth for their secondary school work experience.

What have you done since being on the scheme in terms of training?

The majority of our training has been personal development. We have four modules which try to make us effective members of an engineering team. I was surprised how heavy the focus is on skills such as communication and team working, rather than engineering itself.

What are your specific roles on ExoMars and other Astrium projects?

My role on ExoMars is to integrate the system that gets the picture from the cameras and sends it to the navigation software which generates 3D maps of the terrain. The software then detects dangerous rocks and high gradient slopes and generates a path to avoid them. I've also spent some time on system engineering for the MIRI (mid infrared instrument) on the James Webb Space Telescope, which will be the successor to Hubble. There are 27 different universities and institutes across Europe and the USA involved in this project, and Astrium is helping to manage everyone's efforts to build the instrument. It was a great experience working with people from different cultures.

What do you see as your potential career path in the next five years?

I'd like to return to my home department (mission systems) where we look at concepts for new missions in the future.

Future prospects

In spite of the economic downturn, latest analyses suggest that the space sector will continue to expand, such is its commercial importance. A major issue is that of workforce supply. In the USA, 2008 marked the year in which 25% of the aerospace industry became eligible for retirement. In the UK an equivalent crisis point has not yet been reached, but a recent BNSC–commissioned study highlights the concerns that employers in the UK space sector have about filling future vacancies. For those choosing to forge a future career in the space sector, with the right qualifications, the sky really is the limit.

Mythbuster

The UK doesn't have a space programme!

See above.

How can I work in the space industry when there are no UK astronauts?

It is true that there have never been any official UK Government–sponsored astronauts. The first Briton in space, Helen Sharman, was participating in a programme backed by the Russian government and private industry. Astronauts such as Michael Foale, Nicholas Patrick and Piers Sellers have either had dual UK/US nationality or had to acquire US citizenship to be eligible for selection as NASA astronauts. The European Space Agency (ESA) does have a manned space programme but, as yet, the UK does not participate. This situation may change and is the subject of a current BNSC study.

Although the number of humans who have ever flown in space since 1961 totals less than 500, the global space industry employs hundreds of thousands of individuals. The issue of workforce supply as outlined above are relevant across the world. Many UK individuals working in the space sector find demand for their skills across the world. As a sector, the UK space industry has the most highly qualified workforce in UK manufacturing (BNSC statistics).

We are way behind the Americans in space science

In several areas, most notably small–satellite technologies and Earth observation systems, UK space scientists are world–leading. SSTL is a UK company whose expertise has drawn the attention of NASA in its planning for future robotic spacecraft missions. Astrium's work on the ExoMars rover will make it the most sophisticated planetary lander spacecraft ever built.

Teflon and Velcro were spin-offs from the space programme

Untrue – both were developed many years before the Space Age began!

Find out more

- AEA – www.aeat.co.uk
- Avanti – www.avantiplc.com
- British National Space Centre (BNSC) – www.bnsc.gov.uk
- EADS Astrium – www.astrium.eads.net
- ESA's ExoMars mission – www.esa.int/esaMI/Aurora/SEM1NVZKQAD_0.html
- European Space Agency (ESA) – www.esa.int
- Infoterra – www.infoterra-global.com
- Inmarsat – www.inmarsat.com
- Mullard Space Science Laboratory, UCL – www.mssl.ucl.ac.uk
- National Space Centre – www.spacecentre.co.uk
- Science and Technology Facilities Council (STFC) – www.scitech.ac.uk
- SciSys – www.scisys.co.uk
- SEA – www.sea.co.uk
- 'Size and Health of the UK Space Industry 2008' (BNSC) – www.bnsc.gov.uk/7060.aspx
- Space Academy Partnership – www.spacecentre.co.uk/academy
- Space Research Centre, University of Leicester – www.src.le.ac.uk
- Surrey Satellite Technology Limited (SSTL) – www.sstl.co.uk
- UK Civil Space Strategy 2008–2012 – www.bnsc.gov.uk/assets/channels/about/UKCSS0812.pdf
- UKSpace – Trade association UK space industry – www.sbac.co.uk/pages/43611913.asp
- UK Space Directory – www.ukspacedirectory.com
- University of Nottingham's Institute of Engineering, Surveying and Space Geodesy (IESSG) – www.nottingham.ac.uk/iessg
- Vega – www.vegaspace.eu

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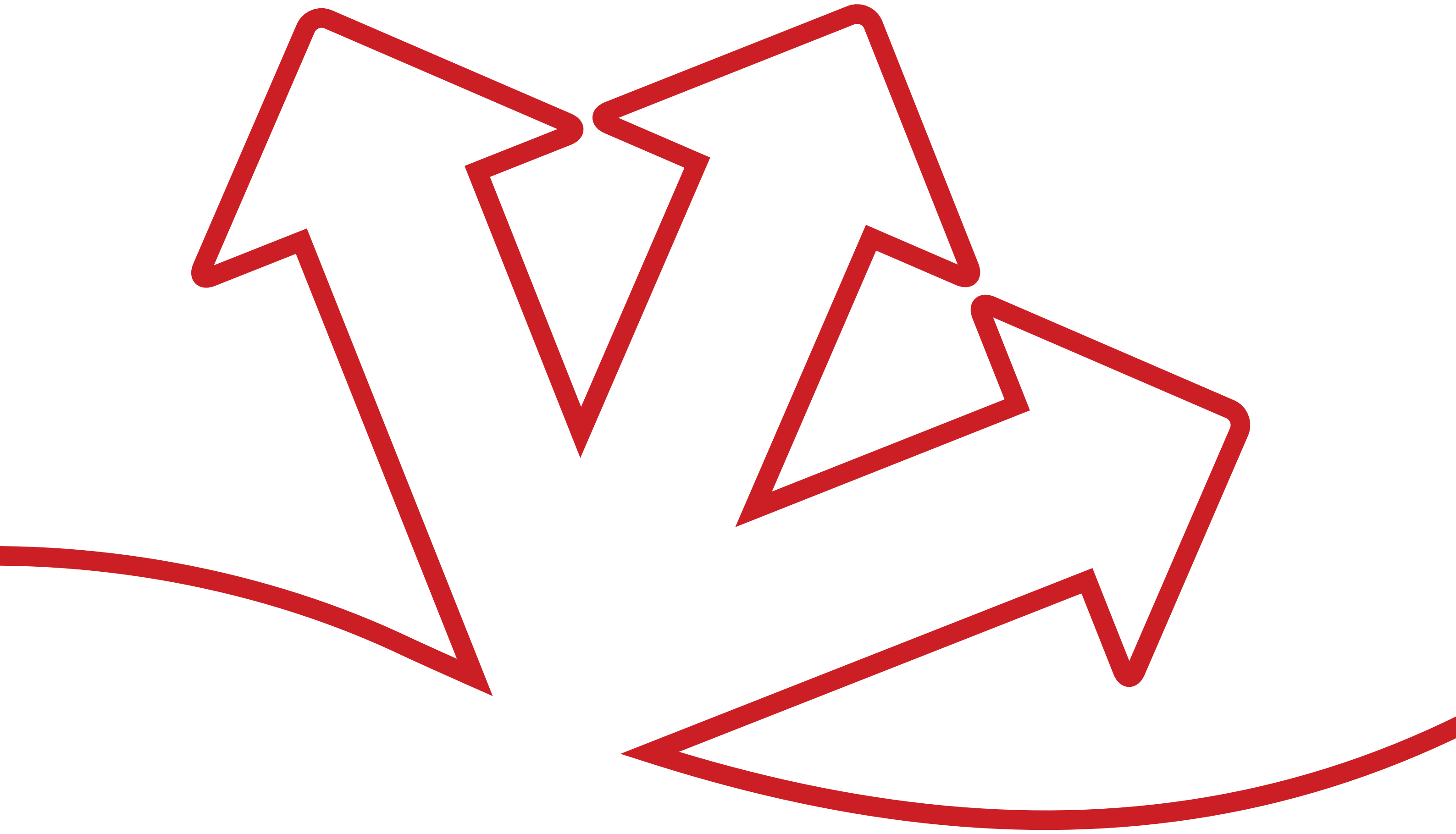

8 Organising STEM Events

Stimulating activities, with links to organisations who deliver inspiring projects

This section provides examples of schemes and activities provided by organisations that aim to enhance and enrich the curriculum. The activities aim to offer a fun and stimulating opportunity for students to see the relevance of their studies to the world of work and to involve industry in its widest sense. The links offer a gateway to the wide range of activities and materials that can be used with different age ranges and within differing curriculum contexts.

STEMNET (Science, Technology, Engineering and Maths Network) – STEM Directories –

www.stemnet.org.uk

STEM Directories are a free resource aimed at helping teachers to pinpoint which activities and events provided by organisations across the UK will enhance and enrich their school curriculum. There are 3 volumes – Science; Engineering & Technology; and Maths. Find out more by visiting: –www.stemdirectories.org.uk/order.asp

Science and Engineering Clubs –

www.stemnet.org.uk/teachers/After_School_Science_and_Engineering_Clubs

The Clubs are aimed at enriching, enhancing and extending the KS3 curriculum. The Club website provides access to resources such as the Clubs handbook and links to suppliers, case studies and activities. In addition two programmes have been produced by Teachers' TV that look at how to set-up and run your own Science and Engineering Club.

Science and Engineering Ambassadors –

www.stemnet.org.uk/teachers/Using_SEAs

Over 18,000 Ambassadors of all ages and backgrounds represent over 1,000 different STEM employers, and have qualities of enthusiasm and commitment along with a passion for what they do. Ambassadors get involved in helping with school competitions, events and awards, offering mentoring and careers talks, and acting as a role model to young learners.

STEMNET has awarded STEMPOINT contracts to a network of local organisations that are able to help identify which schemes or activities can best help schools/colleges to meet student needs.

UK Resource Centre for Women in SET –

www.ukrc4setwomen.org

The 'Employers' pages of the UKRC site highlight companies that offer specific activities such as taster days for females. The GetSET database can be used to search for female role models.

WISE (Women into Science and Engineering) –

www.wisecampaign.org.uk

WISE works creatively with industry and education, offering colourful and innovative tools and approaches to support them in encouraging girls into non-traditional STEM careers. Email info@wisecampaign.org.uk for leaflets, careers mindmaps, postcards. and further information.

NOISE (New Outlooks in Science and Engineering)

www.noisemakers.org.uk

NOISE is fronted by early-career scientists and engineers known as NOISEmakers who aim to communicate the excitement of science and engineering. NOISE is funded by the Engineering & Physical Sciences Research Council (EPSRC) – www.epsrc.ac.uk

More maths grads –

www.moremathsgrads.org.uk/teachers.cfm

This resource will emphasise the career options opening up to students who take their mathematical study beyond GCSE. The project will improve understanding of maths and its applications, from designing racing cars to modelling bird flu. In particular, it will highlight the many doors open to graduates with a degree in the mathematical sciences. A series of high quality careers resources are available for use by students, teachers, and careers advisers. The resources will be available nationally on the www.mathscareers.org.uk website.

Smallpeice Trust STEM enrichment days –

www.smallpeicetrust.org.uk

In-school event organisers for STEM activities

The Industrial Trust –

www.industrialtrust.org.uk

The Trust will organise themed STEM-related events for/with schools.

Go4SET –

www.go4set.org.uk

Project based activity to support subject choice decisions.

Greenpower F24 –

www.greenpower.co.uk/racing/formula24.php

Enable schools to compete in building electric cars which culminates in a race.

Enterprising Science (supported by BP) –

www.enterprisingscience.com

Includes arranging an in-school roadshow.

BAE Systems Schools Roadshow –

www.baesystems.com/education

Offers a science and design & technology theatre production plus a one hour workshop, carried out in schools.

STEM Impact on the curriculum

STEM enrichment and enhancement activies can have a powerful effect on young people's learning and career development. In order to measure the impact of these activities, and provide a continuous improvement strategy, the following framework sets out four different levels of performance and provides a ladder of progression

Level 1 – low level impact
Level 2 – some awareness and use of STEM activities
Level 3 – widespread knowledge and use of STEM activities
Level 4 – whole school approach to supporting STEM activities

Level 1

Enhancement and enrichment activities

Rare use made of enhancement and enrichment activities.

Level 2

Enhancement and enrichment activities

Some use made of STEM enhancement and enrichment activities with some pupils, though this tends to be only with those already committed to STEM subjects.

Level 3

Enhancement and enrichment activities

Good use of STEM enhancement and enrichment activities with substantial numbers of students. High level of awareness amongst staff of the opportunities and benefits of this approach and of STEM Directories.

Level 4

Enhancement and enrichment activities

Whole school approach to STEM enhancement and enrichment. Progressive programme for Key Stages 3, 4 and post–16.

Support for students to reflect on learning and the connections to and implications for career choice

9 Where To Find More Information

Sources of references and websites, including Sector Skills Councils, and finding out about your local area

This section offers a gateway to accessing key information relating to STEM subject choice, career pathways, and resources. The content is not intended to be exhaustive, but aims to save you time by pinpointing sites that will provide the most stimulating and relevant STEM information.

CRAC: The Career Development Organisation –

www.icould.com

A site that provides access to the career experiences of real people through their stories. It includes many inspiring examples of STEM careers at a variety of levels, and through the stories, describes the pathways of people who used their STEM courses as a springboard into other opportunities.

Institute of Biology –

www.iob.org

The IOB aim to encourage a passion for biology in students, and help teachers with resources such as the BioEd e–newsletter and free online lesson plans.

Institute of Physics –

www.iop.org

The Institute of Physics careers service promotes physics through providing information for teachers in the section Careers: Schools and Colleges.

Jobs4u –

www.connexions–direct.com/jobs4u

Comprehensive careers database including the section: Explore Science & Maths.

National Guidance Research Forum (NGRF) –

www.guidance–research.org

A comprehensive site for exploring labour market information. Managed by the University of Warwick Institute for Employment Research (IER) and the International Centre for Guidance Studies at the University of Derby (iCeGS).

Royal Society of Chemistry –

www.rsc.org

The RSC provides a vast range of support for members including publications and a confidential specialist careers service.

Science Council website –

www.futuremorph.org

Launched in November 2008 by the Science Council, with partner support, this inspirational site illustrates that studying science and maths at school can help young people no matter which job they go on to pursue. The site explores the world of STEM through case studies, job profiles, videos, and lesson plans.

STEM Directories -

www.stemdirectories.org.uk

Site to download the STEM directories (for enhancement and enrichment of the curriculum).

STEMNET –

www.stemnet.org.uk

Science, Technology, Engineering and Mathematics Network.

The Association for Science Education –

www.ase.org.uk

Professional association for teachers of science. Includes membership details, publications, INSET, conferences, journals and resources.

www.schoolscience.co.uk

ASE site for teacher resources.

The Centre for Science Education (CSE) –

www.shu.ac.uk/research/cse/

CSE is a research and business development unit specialising in the STEM subjects. CSE creates, manages and delivers resources, projects and initiatives to support teachers and students at all levels of education.

The Council for Mathematical Sciences website –

www.mathscareers.org.uk

This site is the responsibility of the Council for Mathematical Sciences, comprising The London Mathematical Society, The Royal Statistical Society, The Institute of Mathematics and its Applications, The Edinburgh Mathematical Society and The Operational Research Society. Includes a range of resources to support teachers in the classroom as well as parents at home.

The Design and Technology Association –

www.data.org.uk

The Design and Technology Association offer curriculum support through DCSF funded projects such as CAD/CAM in schools, Electronics in schools (with support from the Institution of Engineering and Technology) and Food in schools.

The Engineering and Technology Board (ETB) –

www.etechb.co.uk

ETB's mission is to improve recognition within UK society of the importance of engineering and technology. ETB aims to help counteract the often negative perception of science, engineering and technology and provide links to careers support and events to achieve this.

The ETB site provides links to the numerous professional Institutes which represent the interests of all the branches of engineering and help to promote the importance of the sector.

The Institution of Engineering and Technology –

www.theiet.org/education/

The Institution of Engineering and Technology offers schools and colleges science, engineering and technology curriculum support.

To help in finding the right science course in higher education, view –

www.science-engineering.net

UK Resource Centre for Women in SET –

www.ukrc4setwomen.org

National programme that can provide statistics and materials relating to increasing the number of females in science, engineering, technology and the built environment.

Sector Skills Councils (SSCs) and Industry Focus websites and resources

Cogent –

www.cogent-ssc.com

Cogent host an interactive 'Careers Pathways' site for the Chemical, Pharmaceuticals, Nuclear, Petroleum, and Plastics & Rubber (Polymers) industries.

Enginuity –

www.enginuity.org.uk/resources/other_links.cfm

This link will provide a complete list of all the SSCs.

eskills –

www.e-skills.com

e-skills aims to transform attitudes, inspire interest and prepare young people with the technology-related knowledge and skills employers need. The site provides information on career opportunities and the skills required for a career in IT and Telecommunications.

Scenta –

www.scenta.co.uk

Scenta has been initiated by The Engineering & Technology Board (ETB) to provide a gateway to the best information and resources for those pursuing a career in science, engineering, and technology. The site includes a role model search, inspirational engineering projects, and updates on Broadband Britain.

Sector Careers Link –

www.sectorcareersinfo.co.uk/newsletter.cfm

The quarterly e-newsletter which will provide updates from Sector Skills Councils on their activities supporting careers.

SEMTA –

www.semta.org.uk

The Sector Skills Council for science, engineering and manufacturing technologies. Eight different industry focused sections with information on funding, training information and skills: Areospace, Automotive, Electrical, Electronics, Marine, Mechanical, Metals and Biosciences.

Summitskills –

www.summitskills.org.uk

Summitskills work with JTL (the leading training provider to the building services engineering sector) who have undertaken positive action programmes and succeeded in encouraging more females into plumbing and electrical careers as well as developing a resources pack.

Industry Focus – Space Technology

National Space Centre, Leicester –

www.spacecentre.co.uk

The National Space Centre offers an educational facility with a vast array of interactive challenges, audio–visual presentations and hundreds of artefacts charting mankind's desire to reach beyond the Earth. Many strands of the National Curriculum are covered at each Key Stage, including science, ICT, and maths.

Space Academy Partnership –

www.spacecentre.co.uk/academy

The Space Academy is a partnership between the National Space Centre, the University of Leicester, University of Nottingham, Science Learning Centre East Midlands, STEMNET and East Midlands Development Agency. The Academy programme provides a range of curriculum–based activities that use the contexts of space and climate change to boost learners' engagement and understanding in STEM subjects.

Classroom websites and resources

BAE Systems –

www.baesystems.com/education

As well as a wealth of free resources, curriculum support includes a touring theatre production designed to inspire young people about science and engineering, and 300 employees acting as Ambassadors.

BLOODHOUND Education Programme –

www.bloodhoundssc.com

The BLOODHOUND Project aims to break the world land speed record and through its Education Programme enables schools to access teaching and learning materials to see how the project is developing. Visits can also be made to the University of the West of England, Bristol, to see how the car is shaping up.

BP –

www.bp.com/bpes/cft

Carbon footprint toolkit containing interactive CD–Rom, lesson plans, 3D animations, starter activities, how to calculate your school's carbon footprint.

British Gas –

www.generationgreen.co.uk

Fun online student activities including building an energy efficient house or fixing the online interactive house that is wasting a lot of energy.

BT –

www.connected–earth.com/LearningCentre

From telephone to telegraph to wireless to computer, including good animations such as showing which bit does what inside a mobile phone.

Careersbox –

www.careersbox.co.uk

Over 100 short career, learning and training film clips, including STEM related employment situations.

Engineering Development Trust –

www.etrust.org.uk

Independent charity that run schemes nationwide to inspire young people into STEM careers by giving them experience of industry, business and higher education through events, placements and projects.

Enginuity –

www.enginuity.org.uk

Free and downloadable engineering and technology careers resources online. To help make choosing the various careers information materials an easier task, enginuity produces the UK's most comprehensive online catalogue of STEM–related careers resources:– www.enginuity.org.uk/resources/online_careers_catalogue.cfm

Equality and Human Rights Commission –

www.equalityhumanrights.com

'Be Inspired' role models, and a selection of posters featuring inspirational women.

e–skills uk in schools –

www.e–skills.com

In November 2008 e–skills UK launched a campaign that gives young people an insider view of technology careers. BigAmbition is designed to inspire 14–19 year olds by demonstrating the wide range of IT career options, and how to get into them. The site features interactive tools and video profiles of IT professionals – go to: www.bigambition.co.uk

Learning Grid –

www.learninggrid.co.uk/initiatives

Activities showing modern engineering.

London Engineering Project –

www.thelep.org.uk

Part of the 'Shape the Future' campaign run by The Royal Academy of Engineering, producing useful resources for inspiring girls and BME young people to consider STEM.

Making the Modern World –

www.makingthemodernworld.org.uk

Powerful stories about science and invention from the eighteenth century to today, using the web and dynamic multimedia techniques to go beyond the Science Museum static exhibition.

NHS Careers –

www.nhscareers.nhs.uk

Extensive careers site including lesson plans and supporting materials together with the 'Step into the NHS' website.

NPower –

www.npower.com/education

An easy guide to energy with information sheets providing students with real life skills.

The Nuffield Foundation –

www.secondarydandt.org

Free Design & Technology curriculum materials.

Planet Science –

www.planet-science.com

Site for teachers and young people (originally set up for science year) to enhance the teaching and learning of science.

Planet SciCast –

www.planet-scicast.com

Young people already have the technical skills to record and edit video, and the technology is getting simpler and more streamlined all the time. SciCast enables young people to make films about the impact of STEM to modern life.

Science and Maths –

www.scienceandmaths.net

Includes inspirational case studies including designing sports equipment, developing the latest fashion cosmetics, and sound engineering.

Science Career Videos –

www.vega.org.uk/video/series/10

These videos show a day in the life of a young scientist, giving insights into the lives of young people at the cutting edge of British science and engineering – these are the people who are making things happen.

Science Learning Centres –

www.sciencelearningcentres.org.uk

Provide quality continuous professional development for everyone involved in science education, with a network of 10 centres nationwide providing innovative and inspiring courses.

Science: (So what? So everything) –

www.sciencesowhat.direct.gov.uk

Shows how science touches everything in life through human interest stories through videos and case studies. Great for ideas for lesson plans and projects.

Science Upd8 –

www.upd8.org.uk

Provides short downloadable, easy to use science classroom activities based on up to the minute science in the news and popular culture with a growing STEM career section.

The Association of the British Pharmaceutical Industry –

www.abpischools.org.uk

Biotech is a resource that aims to examine the technology and concerns associated with developments in genetics, including diagnosing disease, medical biotechnology, and neuroscience.

The Association of Teachers of Mathematics (ATM) –

www.atm.org.uk

ATM aim to provide teachers with the resources to help them develop their maths teaching in creative and broad-thinking ways. FREE resources are provided on their website for teachers to download or use online in the classroom.

The Council for Mathematical Sciences –

www.mathscareers.org.uk/teaching_resources.cfm

This link will provide access to exciting classroom resources that emphasise the transferable skills that maths provides for students, whatever jobs they eventually enter.

The Geological Society -

www.geolsoc.org.uk

Free curriculum materials and visiting speakers will inspire students to consider geoscience, where there is increasing demand for students in civil engineering and associated industries that are seeking to make the best use of the planet's resources.

The IET (Institute of Engineering and Technology) Faraday -

www.theiet.org/faraday

Award winning programme of resources, activities, competitions and events designed to inspire young people about STEM, including a free, high quality interactive website.

The Institute of Mathematics and its Applications -

www.ima.org.uk/careers/school

Maths careers resources including posters, and careers information for teachers and careers advisers.

UK Resource Centre for Women in SET -

www.ukrc4setwomen.org

The resources section provides access to a range of information and initiatives relating to girls and women in science, engineering and technology. The SET Directory includes links to a plethora of groups and websites tackling issues that contribute to female under-representation in STEM. The Publications Catalogue hosts over 4,000 items, including promotional material and articles. There is also a fully searchable listing of case studies and role models showing women at all stages of their careers. Use the 'enquiry' facility to request information and resource materials such as posters and leaflets.

www.ukrc4setwomen.org/html/education/careers-professionals

Access this site to find out about the Let's TWIST gender equality training run by UK Resource Centre for Women in SET. The training materials have been developed for anyone involved in providing information, advice or guidance to young people, and illustrates the importance of challenging occupational segregation and gender stereotyping.

Why not chem eng –

www.whynotchemeng.com

Contains careers website, lesson resources, posters, real life case studies, live graduate and student blogs.

WISE (Women into Science Engineering and Construction) –

www.wisecampaign.org.uk

WISE works creatively with industry and education, offering colourful and innovative tools and approaches to support them in encouraging girls into non-traditional STEM careers. Email info@wisecampaign.org.uk for leaflets, careers mindmaps, postcards. and further information.

Working in....booklets –

www.vtlifeskills.co.uk

Attractive high quality careers information booklets that include Science, Manufacturing, Hospitals, the Built Environment & Construction, Transport & Logistics.

YWCA –

www.ywca.org.uk

YWCA work with the most disadvantaged young women and seek to tackle occupational segregation and gender stereotypes through programmes, games and interactive discussions including the 'Play your cards right' game.

Finding out about your local area

Accessing local and Regional information will help young people to identify the STEM pathways in their area. The following are examples of where local and regional information can be located.

Online 14-19 Area Prospectus –

www.local.direct.gov.uk/LDGredirect/index.jsp?LGSL+1145&LGIL+8

Use your local 14-19 online Area Prospectus to find out about the wide range of courses and learning programmes offered by education providers in your area.

Increasingly an electronic version of the Common Application Form is being used for entry to post-16 learning – check the procedure used in your local area.

Local and Regional Labour Market Information – NGRF (National Guidance Research Forum)

www.guidance-research.org

NGRF (National Guidance Research Forum) website is created and maintained by guidance researchers and practitioners. The partnership involved in the development of the site includes the University of Warwick Institute for Employment Research (IER) and the International Centre for Guidance Studies at the University of Derby (iCeGS).

This site can be used to explore labour market information in your area. Choose the LMI Future Trends section and click on national, regional & local data to access industry profiles and labour market statistics including all STEM-related sectors.

Local Connexions Services

Connexions Services serving your area will have access to local LMI, and may have an LMI Specialist within their team producing bulletins and newsletters which provide updates on local and regional labour market activity.

Learning and Skills Councils –

www.lsc.gov.uk/regions

LSCs are a source of local and regional LMI, including publications and research papers and surveys. Select your region to be able to locate LMI for your area.

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)

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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**

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