Teaching and Learning Programme

Post-16 Participation in Science, Technology, Engineering and Mathematics (STEM): Interim Report

Contents

Please note the annex for this report can be found in the associated document *Post-16 Participation in STEM Interim Report: Annex.pdf*

The UK is well placed to take advantage of the new markets opened up by globalisation. We have an extraordinary record of scientific discovery and a rapidly growing share of high-technology manufacturing and knowledge-intensive services in the UK's GDP. The amount of knowledge transfer from British universities has increased significantly and we are beginning to see the growth of exciting high-technology clusters around many of our world-class research universities.

A major campaign to enhance the teaching of science and technology including raising the number of qualified STEM teachers, increasing the number of young people studying triple science, improving careers advice, establishing a National Science Competition, and rationalising the many schemes to inspire our young people to take up careers in science and engineering.

Sainsbury Review of Science and Innovation: 2007

1. The purpose

1.1 The Post-16 STEM Programme, part of the Teaching and Learning Programme, investigated the gap between the numbers of learners studying science, technology, engineering and mathematics (STEM) in schools (at A-Level), and those studying STEM subjects in Further Education[1](FE).

1.2 Lord Drayson, the Minister for Science and Innovation, has described the importance of ensuring that the UK workforce has the right mix of skills to increase the national capacity to innovate[2]. The FE sector has a strategically important role to play in contributing to the necessary improvements, as set out in the section on context below.

1.3 The research project analysed and consolidated existing data in the following areas:

- science, mathematics and engineering in FE;
- progression from GCSE to A-Level in FE;
- take-up of A-Levels within FE as compared to schools and sixth forms;
- technician grade training in engineering;
- what lessons can be learned from preparation for progression to HE including physics, chemistry, mathematics and biology?

1.4 Through data analysis, research reviews and case studies, the researchers investigated the following areas:

- how data across FE is collected and organised, and how this contributes to our understanding of the situation;
- how FE provision is organised and how this contributes to participation and progression;
- teaching and learning issues within FE in relation to transition and progression;
- learner perspectives on studying in FE or in school settings;
- the effect of gender on progression.

[1] Further Education comprises providers of post-compulsory education and training, which includes teachers, trainers and tutors working in general further education and sixth form colleges, work-based learning providers and organisations supporting community learning and development
[2] DIUS, Annual Innovation Report, 2008

1.5 These questions are urgent in the context of the new report commissioned by DIUS (January 2009), 'The Demand for Science, Engineering and Mathematics (STEM) Skills'. This is in response to 'Innovation Nation' and its findings indicate a set of problems that FE should be central to solving. The core problem is that, although the supply of STEM graduates and postgraduates has increased between 2002-2007, albeit with differences between subjects, the STEM pipeline looks significantly less healthy. As Professor John Holman, National STEM Director, has pointed out, there has been a period of relative decline in the take-up of STEM A-Levels both in absolute terms and as a proportion of the A-Level cohort which has increased by 18.5% in the last 10 years.

1.6 This situation is exacerbated by demographic changes which are projected as resulting in a very significant downturn (2009-2020) in the relevant young populations in all four countries of the UK. This suggests that the needed growth may have to come from the older cohort (30-39) and by both plugging leaks in the STEM pipeline and supporting STEM take-up, persistence and achievement in both school and FE contexts.

1.7 Given the importance of FE to this situation, this report is intended to draw a picture of what we know in FE; to enable the identification of gaps in the existing research base and to develop strategies to address them. It is worth registering that the policy and learning landscape for FE has been constantly changing in terms of governance, targets, audit processes and funding, and this is beginning to be mapped and analysed in various TLRP[3] research exercises. This could well have an impact on the investment in and delivery of STEM and STEM-related subjects and will need exploring in the review of existing research and any proposed new research.

This report also describes some of the ways in which providers are successfully addressing many of the challenges and barriers identified in the research, and makes initial recommendations both to increase our understanding of the FE sector and from that, to begin increasing STEM opportunities and closing the progression gap for learners.

1.8 The report will identify ways in which the new Post-16 STEM Programme as part of the LSIS Teaching and Learning Programme[4], will support providers in taking forward these recommendations. The Post-16 STEM Programme is the only programme in Further Education entirely focussed on issues around STEM and on supporting the teachers and providers of STEM subjects.

2. The national context for STEM

2.1 There has been a series of reviews and reports highlighting the urgent need for the UK to improve its performance in the skills, science and innovation capabilities of its people and economy. The current downturn only serves to demonstrate the global nature of world trade and finance and underwrites the clear messages coming from the Lambert Review (2003), the Science and Innovation Framework (2004), the Leitch Report (2006), the Sainsbury Review (2007) and Innovation Nation (2008). Indeed, the very establishment of DIUS brings together the three major drivers of 21st century economic success – skills, science and research and innovation.

[3] TLRP - Supporting and developing UK educational research to improve outcomes for learners of all ages. http://www.tlrp.org/

[4] Learning and Skills Improvement Services- The Programme aims to support providers to improve the quality of teaching and learning by linking organisational strategies for quality improvement, continuing professional development and the Subject Learning Coach model. http://teachingandlearning.qia.org.uk/teachingandlearning/

2.2 The recent report (January 2009) from the Council for Industry and Higher Education (CIHE), 'The Demand for STEM Graduates and Postgraduates', celebrates the work of the National STEM programme and the appointment by HEFCE of the University of Birmingham to lead a STEM partnership of the Royal Society of Chemistry, the Institute of Physics, the Royal Academy of Engineering and a consortia of mathematics societies. However, it describes the challenge that they face in stark terms in its response to the DIUS consultation, 'Higher Education at Work':

> *We cannot stress too forcibly our concern at the critical shortage of graduates and post-graduates with STEM capabilities. This is a burning platform that has to be addressed or the UK will not remain competitive.*

2.3 Given the fragility of the UK's position against global competition and the importance of 'feeding' knowledge-intensive industries, the report stresses the need to open the eyes of the young to the opportunities that studying a STEM subject offers. This is reflected in the recently commissioned University of Warwick IER report (2008) which reveals that, based on past employment figures, demand for STEM graduates and postgraduates in both 'expansion' and age-related 'replacement' terms, will grow significantly faster than the average for all subject groups and across a number of sectors:

- **Manufacturing:** the rate of growth of employment for STEM graduates is faster than elsewhere, despite overall worse employment prospects;
- **Non-marketed Services**, such as education, health, public administration and defence, is the sector with the largest share of STEM-qualified employees;
- **Business and other services** account for even greater numbers of STEM graduates and postgraduates than the public sector;
- **Distribution and transport** employ significant numbers;
- **Primary sector and Construction** employ a comparatively small but significant number of STEM qualified employees.

2.4 The CIHE report recognises that some of the latest school and university data is encouraging but comes on the back of a steady, long-term decline. Figures from UCAS show that in 2008-2009 universities' acceptance of students in mathematics have risen by 8.1%, chemistry by 4.4%, physics by 3.3% and engineering by 6.4%. These increases appear to build on an emerging trend from 2005 - 2008, reflected in the increase in A-Level entries in mathematics (15.7%), further mathematics (29.5%), chemistry (5.3%) and physics (4.4%).

2.5 However, the ETB report 'Engineering UK' (December 2008) points out that although there are positive findings on both undergraduate take-up and graduate destinations in engineering, their analysis suggests a serious shortage of technician-level engineers in the more junior occupational groups. These would tend to come through an FE route and their lack is serious, these occupations being described as the bedrock upon which engineering depends – although as the recent DIUS Report (2009) on STEM skills points out, engineering is one of the largest apprenticeship areas with over 19600 'starts' in 2006, with over two thirds at Level 3 and a further 9000 places in Manufacturing Industry being announced in 2008. The report also sees the 14-19 diplomas in engineering, IT, construction and the built environment as potentially important in allowing both FE and HE progression.

2.6 What is interesting, and part of the problem in terms of post-16 progression, is that the CIHE report barely mentions FE. This rather underlines Sir Andrew Foster's observation in his 2005 review, 'Realising the Potential: a review of the future role of FE Colleges' that FE was '**the neglected middle child'**. Government however has identified a crucial role for FE in terms of Business Innovation Services and Knowledge Transfer into the small and medium business sector and the provision of industry-standard vocational training, embedded in the dual requirements of the Standard for Employer Responsiveness and Vocational Excellence.

2.7 The recent 2008 DIUS launch of the FE Specialisation and Innovation Fund attracted huge interest from the FE sector, and the five chosen Pathfinder projects all represent sectors with a very high level of STEM requirement and a close working relationship with the industry sectors concerned. They included aerospace, construction, land and marine-based, engineering and financial sectors. These sectoral descriptions give one indication of the issues in understanding what FE offers in terms of STEM-related subjects and how it organises itself.

3. The post-16 context for STEM progression

3.1 In the world of education and training there are headline concerns, outlined by Professor John Holman, National STEM Director, in his recent 'A framework for STEM coherence' address at the National Science Learning Centre, University of York. These can be summed up in two quotes:

'There are two areas of improvement in the STEM initiative: one is attainment, we want those taking STEM subjects to do better in them, and the other is engagement, we want more young people to take STEM subjects particularly post-16 and beyond.'

'The aim is to enable those organisations outside government to collaborate with government initiatives and identify what needs to be done and assign their resources in ways that make the biggest difference. In this way teachers and lecturers will still have considerable choice, but the support they choose will have the potential for maximum impact.'

3.2 The desirability of these objectives were illustrated by showing the declining or static trends in the A-Level entries for physics, chemistry and mathematics over 30 years and the results of the 2007 PISA study involving 57 countries, where the UK had mixed results against both the OECD and partnership countries – despite the recent improvements noted in the CIHE report. These concerns are echoed by the CBI which estimates that the UK will need to double the number of science graduates over seven years or see skilled jobs disappear.

3.3 The government's response to this problematic landscape has been to develop the DCSF / DIUS STEM Programme[5], an extensive programme addressing:

- STEM workforce numbers;
- workforce quality;
- post-16 take-up;
- engagement and stretch;
- qualifications, curriculum reform;
- STEM coherence.

[5] STEM Programme Report (DCSF 2006)

It is also one of the fundamental reasons for LSIS establishing the Post-16 STEM Programme as part of the Teaching and Learning Programme (TLP). Prior to this there was no programme in FE entirely focussed on the issues around STEM.

3.4 Professor John Holman estimates that there are over 200 government and non-government funded initiatives in the STEM field. The strategy set out in the STEM Programme seeks to achieve coherence and effectiveness through sorting these local, regional and national initiatives into 10 Action Programmes covering five broad headings:

- recruitment of teachers and lecturers;
- continuing professional development of teachers and lecturers of mathematics, science, engineering and technology;
- enhancing and enriching the curriculum both inside and outside the classroom;
- actions to improve the formal curriculum;
- improving infrastructure and delivery mechanisms.

3.5 There is already significant evidence as to what constitutes good pedagogic, developmental and organisational practice in STEM areas with respect to encouraging and supporting learners into post-16 progression. The Secondary National Strategy has published its 'Progression to post-16 science: interim report' (2007) which continues the process of understanding and identifying the common features, forces, factors, processes and policies that contribute to high take-up of post-16 science. In parallel, the National Centre for Excellence in the Teaching of Mathematics (NCETM) has studied the factors in schools that lead to progression from GCSE to A-Level Mathematics. Both studies demonstrate that a range of strategies need to be deployed together to improve progression, particularly involving specialist teachers, other subject teachers, team leaders, senior management and the external world. Not surprisingly, these characteristics align with the more generic Ofsted description of what constitutes a good school and good teaching and learning. Furthermore, they align with the principles underpinning the TLP in terms of effective practice and whole organisation approaches.

3.5 What is obviously common to both studies is the central importance of the teacher. The recent McKinsey study, 'How the world's best performing school systems come out on top' (2007) says clearly:

Above all, the top performing systems demonstrate that the quality of an education system ultimately depends on the quality of its teachers.

4. The current state of progression from GCSE to A-Level in FE

4.1 This report focuses on the current evidence for progression from school to STEM subjects in FE. The overview positions in the report are derived from work commissioned from the Leeds University School of Education, the East Midlands Centre for Excellence in Teacher Training (EMCETT), SE data analysis undertaken by Stephen Banham[6], evidence from the LSIS Post-16 STEM Programme and from the project steering group. The phenomenon they were being asked to research or review is laid out in stark terms in the graph and tables below[7].

[6] See Annexes to this report
[7] Graph and tables from Prof John Holman

Graph A – the proportion of the population of 17-year-olds taking biology, chemistry, mathematics and physics at A-Level over 30 years demonstrates the static or declining nature of STEM A-Level take-up in this time period. However, notice the small upward blips for mathematics and chemistry from 2005.

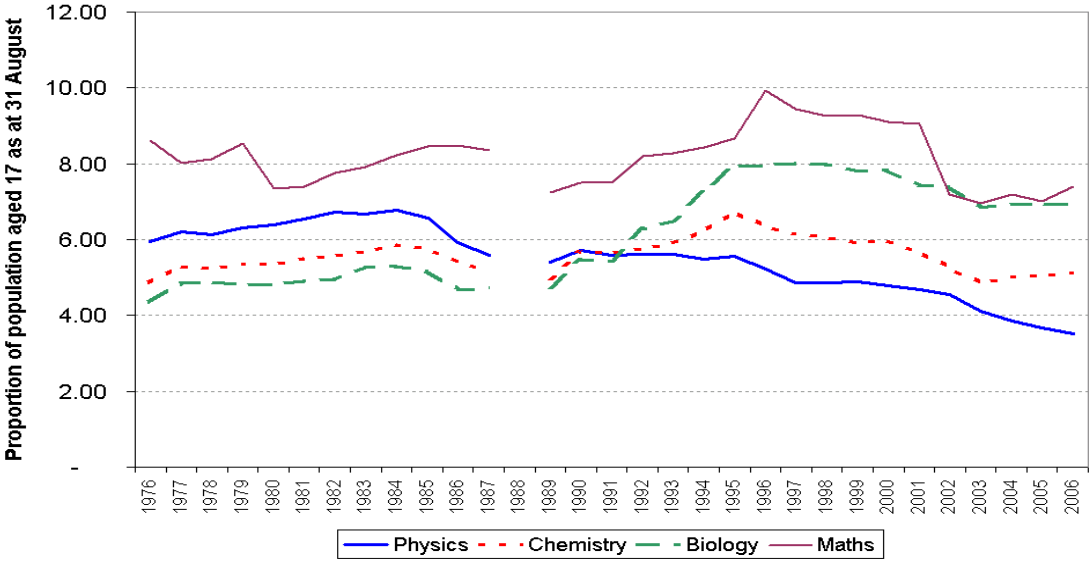


Table A – A-Level entries 1996-2006

A-Level Entries	1996	2006	Percentage change
All A-Levels	620,164	715,203	+15.3%
Chemistry	34,677	34,534	-0.4%
Physics	28,400	23,657	-17%
Mathematics	35,007	30,637	-12.5%
Further Mathematics	4,913	6,516	+32.6%
Biology	43,398	46,624	+7.4%
Other sciences	4,194	3,599	-14.2%
Design & Technology	8,986	16,708	+86%

These reflect a 10-year time period but the most recent data from 2005 - 2008 show encouraging upward trends in mathematics, further mathematics, physics and chemistry, reflected in improved undergraduate uptake figures (UCAS) in these subjects and engineering, although with significant distance to be travelled if the demand volumes predicted by CBI and IER are to be achieved.

Table B: A-Level subject gender ratios – ranked

subject	m:f ratio
physics	1:0.26
other science	1:0.37
further mathematics	1:0.41
mathematics	1:0.62
design & technology	1:0.71
chemistry	1:0.94
biology	1:1.41

These figures reflect a significant opportunity to address the volume problem through strategies targeted at females – even more so in engineering where female take-up is low.

Summary 1996 - 2006 A-Levels

- Data on A-Level entries and pass rates are readily available and can be analysed and reported reasonably easily with little resource.
- A-Level entries have increased over 12 years and female learners now make up more than half of the entries but not reflected in the majority of STEM subjects, except chemistry and biology which is probably linked to the requirements to study medicine.
- Some subjects like media/film (236%), ICT (186%), psychology (169%) have grown substantially over 12 years. However, subjects like French, German, computer studies and economics have declined.
- In the STEM subjects, entries in physics and mathematics have declined, whilst chemistry and biology appear robust, although nowhere near matching the growth subjects such as media and psychology.
- Pass rates at A-Level have improved since 1996 and, with the exception of mathematics, there was a noticeable increase in 2001 - 2002 following the introduction of Curriculum 2000. Again, the more recent figures for 2005-2008 show a more encouraging trend for this subject.
- Subjects such as computing, physics, mathematics and economics have more male than female learners. Chemistry is almost a 1:1 ratio, possibly related to the requirements of medicine, and females dominate biology.

5. What the research review tells us about Post-16 progression in FE STEM

5.1 The brief was to:

- Consolidate existing research by conducting a systematic review of research in the areas of project scope:
    1. Progression from GCSE to A-Level in FE*
    2. Take up of A-Levels within FE as compared to schools and sixth forms
    3. Science, mathematics and engineering in FE
    4. Technician grade training in engineering

5. What lessons can be learned from preparation for progression to HE including physics, chemistry, biology, engineering and mathematics
6. Identify and plan research strategies to meet gaps in the existing research base.

The research references and databases searched can be accessed in Annex 1 (Appendix 1, STEM References).

5.2 Basically the researchers found much that is related to the transition from school to post-16 issue and much that is tangential, but little that addresses directly the issues of enrolment, retention and progression in STEM subjects in FE. In particular:

- **They have not been able to find the disaggregated data in DCSF, LSC, Youth Cohort Study, HEPI, Nuffield and DIUS sources[8], which distinguishes between schools and FE for entries and pass rates in STEM subjects at GCSE and GCE**. It was noticeable that many reports on STEM subjects did not distinguish between schools and further education colleges when reporting entry and pass data.
- **They have not been able to find data for the numbers of learners on STEM subject courses, be they standard STEM courses such as GCSE and GCE or more vocational courses within further education colleges.**
- **They have not been able to find data about the number of learners taking STEM subjects progressing from school FE colleges and again from FE colleges into HE**, although the general prior qualifications of the 2008 undergraduate cohort are broken down in an HEPI report:

Prior qualification group 2008	Total
GCE A-Level	254,620
GCE and VCE A-Level combination	30,420
VCE A-Level	6,075
A-Level equivalent with unknown tariff score	20,150
BTEC	14,170
Other	25,650
Grand Total	351,085

- **They have not been able to determine an agreed, accurate and comprehensive list of all vocational and other courses that might be classified as STEM subjects**. This raises very fundamental questions as to exactly what one is counting. The Learning and Skills Council listed 10075 FE courses (2005/06), of which 428 are classified as ‘Area of Learning 1’, which includes many STEM and STEM-related subject such as:
    1. GCSE Mathematics

[8] www.dcsf.gov.uk – ‘research and statistics’; ‘post-16’; ‘further education’
www.lsc.gov.uk/providers/Data/statistics (success/FEqualifications) (learner/KeyFacts)
www.hepi.ac.uk
www.accreditedqualifications.org.uk
www.Nuffield14-19review.org.uk

2. GCE AS/A-Level Mathematics
3. Key Skills in Application of Number Level 3
4. GCE AS/A-Level Biology and Human Biology
5. GCE AS/A-Level Chemistry
6. Diplomas in Anatomy and Physiology
7. GCE A-Level Physics
8. HNC in Science (Applied Biology)
9. HND in Equine Science and Welfare
10. Numbers Direct – Fractions Stage 2
11. Numbers Direct – Length Stage 3
12. PGC in Biomedical Science

This complexity is compounded by the fact that courses with ‘engineering’ in the title exist in other ‘Areas of Learning’. The National Database of Qualifications[9] lists over 400 L2/L3/L4 for engineering in all its forms: building, water management, safety, automotive, electrical, transportation, aerospace and so on. Equally FE colleges organise their learning in ways that are not immediately transparent in STEM terms.

As an example, Hartlepool College (chosen at random), advertises four STEM-related engineering areas: Aerospace, Operations and Maintenance, Construction Built Environment and Electrical and Mechanical. These will reflect local priority sectors, Regional Economic Strategies and Sector Skills Councils’ areas of accountability rather than STEM as such, although each engineering area encompasses 7 A-Levels and routes through to both HE and Vocational Qualifications. As Professor Sa’ad Medhat, Chief Executive of the New Engineering Foundation, recently commented in ‘Preparing for the Future’ (NEF 2008):

There is a general lack of clarity in what applied and vocational sciences mean to a number of educational institutions, government agencies and policy makers.

5.3 In the same vein, there is lack of clarity with respect to counting learners in FE. The Killeen Lecture (within Appendix 1), given by Professor Phil Hodkinson makes some challenging assertions with respect to common government and policy assumptions about career progression and career decisions. In particular, he argues that there is a wealth of empirical evidence to suggest that the ‘folk theories’ of linear progression do not capture the reality of learners in FE and their movements in and out of courses, careers and employment.

5.4 This has raised a number of issues of data and definition which need to be addressed:

- first, this examination of data has highlighted the importance of looking not only at the raw numbers of examination entries as an indication of change over a period of time. Clearly, headlines which only report the number of examination entries in a subject, without reference to the various routes for GCSE or A-Level entries or the age cohort, could give a misleading and partial impression;
- second, there are serious weaknesses in the evidence base which limit the strength of the conclusions that can be drawn, particularly with respect to time-series data;

[9] www.accreditedqualifications.org.uk

- third, the evidence examined has not provided robust causal explanations of declining or static examination entries in STEM subjects as such. Many of the recurring issues (restrictive curriculum, demotivating assessment regimes, narrow teaching methods) have been raised in relation to subjects perceived to be in a healthier state including history and English.

6. Insights from other analysis

6.1 The post-16 project explored other related reports and had data analysed in both the South East and East Midlands:

1. East Midlands Centre for Excellence in Teacher Training (EMCETT) has produced an interim report on STEM progression[10] to:
    - yield a statistical overview of progression (Level 2 to Level 3) for the whole East Midlands (16-19yr olds only)
    - provide a detailed map of STEM provision within FE in the East Midlands
2. ETB's Annual Report (2008): Engineering UK
3. Analysis of SE progression data
4. Devon and Cornwall LSC: Value for Money 2006
5. DIUS 2009 Demand for Science, Engineering and Mathematics Skills.

6.2 **EMCETT** is one of 11 national CETTs supporting LSIS and the reforms of teacher education for the Lifelong Learning sector. Despite the fact that its interim findings are based on partial data relating to some 2 445 learners from two FE colleges[11], and its full report will not be complete until spring 2009, it has already confirmed some of the trends noted elsewhere in learner numbers and movements between Levels 2 and 3 in science, mathematics and engineering[12].

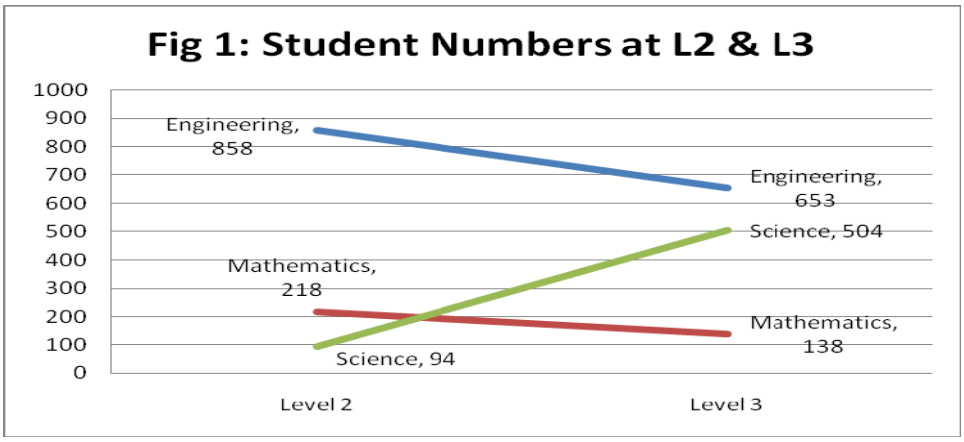
Interim data confirms a decline in learner numbers moving from L2 to L3 in mathematics (science shows a five-fold increase in numbers at Level 3 (Fig1), but this may a result of a partial and skewed interim sample).

[10] See Annex 2

[11] EMCETT's interim report is based on:
Quantitative data in the form of statistical returns made by FE institutions to the Learning & Skills Council (East Mids), and qualitative data through interviews and surveys of STEM Level 3 students, their lecturers and relevant curriculum managers

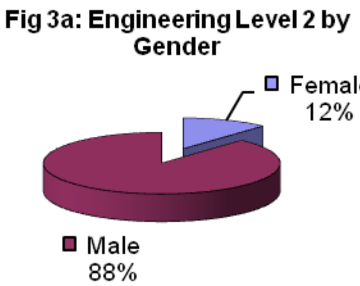
[12] Distribution of students in the study

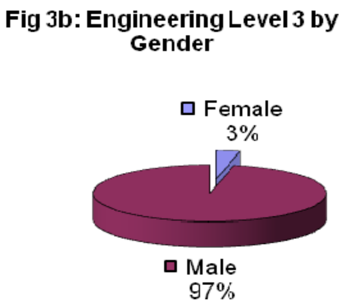
STEM n=2445					
Science L2	Science L3	Maths L2	Maths L3	Engineering L2	Engineering L3
n=94	n=504	n=218	n=318	n= 858	n=633



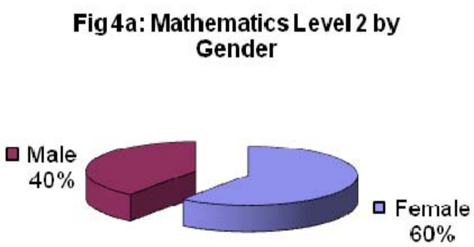
- In terms of **age profiles**, the overall picture is of the relative proportion of 20+ declining at Level 3 compared with Level 2. In **engineering**, the 20+ group are in the majority at both levels but nevertheless decline by 6% at Level 3. **mathematics and science** have a 43 to 44% prevalence of 20+ learners at Level 2 but this proportion declines markedly at Level 3 with mathematics showing the most significant decline from 44% (Level 2) to 7% (Level 3) of the cohort numbers.

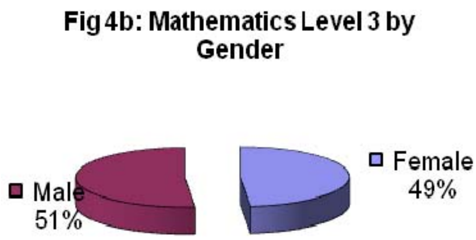
- In terms of gender, females remain under-represented in engineering (and this becomes more pronounced at Level 3).

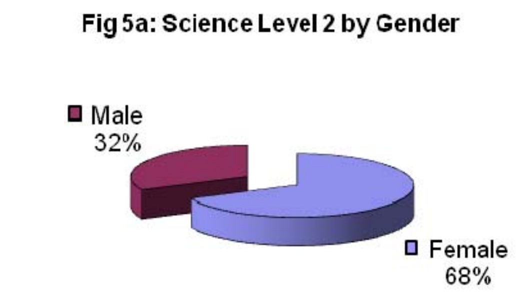


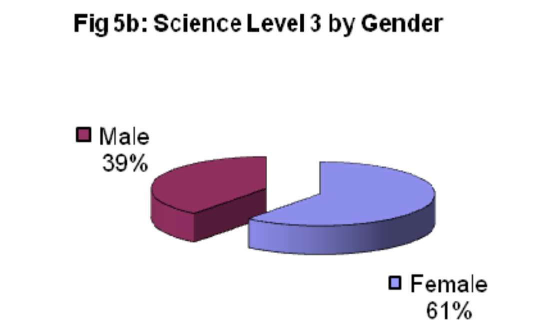


- Mathematics and science are attracting more females than males at Level 2, but again they are less likely to progress to Level 3, especially in mathematics, where females make up 60% of the Level 2 cohort but this declines to 49% at Level 3. In science, female progression is stronger with 68% of the cohort at Level 2 falling only to 61%, at Level 3.

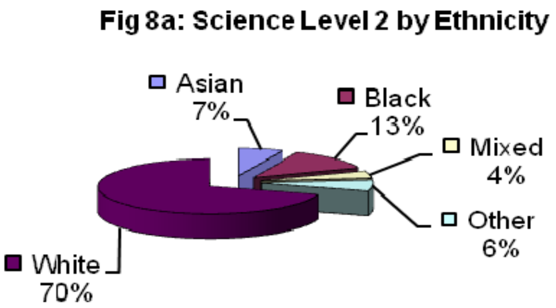


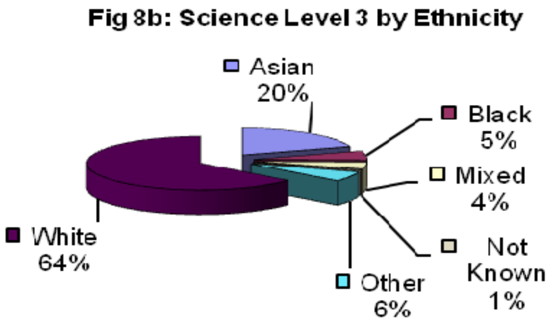




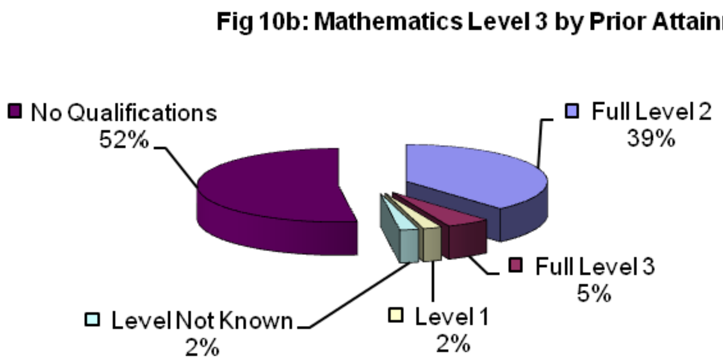


- In terms of ethnicity (defined according to the standard LSC designations), the pattern suggests that Asian learner progression to L3 STEM subjects is good, that White learners are progressing less in mathematics and science but do better in engineering, and that Black learners tend to show less progression to Level 3 across all STEM subjects. The detail for science illustrates this well.





- This study is also collecting data on the prior qualifications learners at Levels 2 and 3 of STEM subjects. Preliminary data shows only small numbers of engineering and science learners coming to their courses with no prior attainment. But in mathematics at Level 3 some 52% of learners joined without prior qualifications.



- This impression has been supported by qualitative data gathered from a much smaller sample (80 learners from five FE colleges), where 62% said they had a relevant GCSE at Grade B or higher, or an AS qualification. A very small sample of lecturers has expressed some dissatisfaction with the prior attainment of learners at Level 3, especially in mathematics.

6.3 **Engineering UK 2008,** the Engineering and Technology Board's annual report, struck an optimistic note overall:

- noting that in the last five years there has been a 7% increase in engineering and technology applications to higher education, and that over the same period the number of graduates has risen by 2%.The report also notes that two thirds of engineering and technology graduates find some employment within six months of graduation and that 90% of these are in engineering and related occupations.
- Of those who took up engineering occupations, most had studied an HE STEM subject, though some had come from a business administration background.

The report also draws attention to the wide gender imbalance in engineering. Although newly registered engineers are some 17% female, the overall percentage of existing female registered engineers remains in the low single figures. This slow rise in the proportion and actual number of female engineers needs to be set against a steady long-term decline in overall numbers. In FE this gender imbalance is even more pronounced (see 3a above).

6.4 **South East FE data analysis**

This project was designed to analyse what is happening within FE with respect to learner movement, achievement and the impact of STEM in its entirety or as an ingredient in learner progression. The data is drawn from the LSC SE data set grid for FE. The grid reflects data from provision across the South East of England; the chosen STEM programmes are from an LSC definition for the subject areas.

From the grid certain key progression facts can be summarised including**:**

FOUNDATION and Level 1:

- from the full population of 1 115 000 foundation learners approximately ¾ million **do not** take up STEM subjects (68%);
- the number of foundation learners progressing to level 2 is insignificant;
- only 12.5% of those who take foundation engineering progress to a level 2 engineering;
- people who do STEM foundation get better chances of progression to level 2 than those taking up general programmes;
- overall only 1.5% of those taking up foundation programmes end up with a full level 2. Whereas those taking up STEM at foundation significantly boost their chances of gaining a full level ;
- 8% of Engineering at Level 1 go onto take up non STEM at level 3;
- engineering at foundation gives a better chance of progression to level 3 compared to other STEM and non-STEM programmes;
- taking a level 1 Key Skills ICT qualification as part of a Foundation programme is the most significant way of ensuring that there is progression to full level 2 – 14.1% progress.

LEVEL 2:

- a South East sample of 10 000 learners taking up science at level 2 increased their chances of achieving a full level 2 from 17.9% to 43.6% compared to those taking any programme;

- if learners take up an engineering programme without mathematics they significantly reduce their chances of gaining a full level 2, figures show the rate of achievement at 23.5%;
- if Key Skills in mathematics is included the likelihood increases to 39.3%, if other mathematics is included the likelihood increases to 52.7%.

LEVEL 3:

- of ‘any’ level 3 programme studied 32.4% of those learners gained a full level 3. However, if part of their programme included science their chances nearly doubled to 62%;
- key skills ICT was the biggest critical factor in getting a full level 3 with 70% progressing to achievement;
- generally of those people taking engineering at Level 3 only 24.5% gained a full level 3;
- learners that did not take up any STEM as part of their level 3 reduce their chances of gaining a full level 3 achievement; only 24% achieved;
- taking up some STEM learning increased and in some cases more than doubled the chance of learners getting a full level 3 ;
- undertaking a level 3 programme with *just* STEM subjects, however, reduces chance of achieving full level 3 to 18.3%;
- if a learner takes up STEM as part of their level 3 study in conjunction with non STEM provision this would prove to be the best way to achieve a full level 3.

All of this information reinforces our belief that STEM subjects can have a significant impact on positive progression whether directly when a STEM area is studied or when there is the addition of a STEM subject area to a programme. This raises the questions of:

- how to ensure that learners are aware of the potential benefits of such study;
- how to provide the best possible learning environment with appropriately qualified teachers and active approaches to learning.

6.5 **Devon and Cornwall LSC: Value for Money and Funding: Year 3 (2006)**

This project was to establish baseline information on added value and value for money for FE colleges and schools with sixth forms in order to improve the quality of 16-18 provision in Devon and Cornwall. This is the third year of the project and this benchmarking allows comparisons to be made from 2002.The objectives of the project were as follows:

- to establish an added value measure for 16-18 learners in each FE college and school sixth form;
- to establish a value for money measure for 16-18 learners in each FE college and school sixth form;
- to provide year-on-year comparisons to allow a deeper understanding of results and an analysis and identification of emerging trends.

Although the project is not looking at STEM subjects as such, it does point up issues as to both funding and effectiveness of schools and colleges. The relative funding gap between schools and colleges has become more polarised with seven of the 10 least well funded institutions in 2005 being general further education colleges. This general observation may have some impact on the provision of STEM subject teaching and be an issue for further research.

6.6 **The Demand for Science, Engineering and Mathematics Skills: DIUS 2009**

This very recently published research emphasises the importance of the STEM pipeline. STEM subject choice at HE is, to a large extent, determined by subject choice earlier on in the education system. At the moment A-Level entries in chemistry and biology are higher than in 1976, physics is down significantly and mathematics is showing a revival – all this against a drop in comparative share of the cohort. 0ne particularly telling diagram[13] illustrates the progression through A-Levels into HE for a cohort of English-domiciled 15-year-olds who were in the maintained sector in 2001/02 and in HE at 19 in 2005/06. It raises a number of points:

- that the greatest 'leakage' from the system is the proportion of young people that do not go on to attain any A-Level qualifications at all (372 900 or two thirds) although they may attain other types of Level 3 or vocational qualifications;
- that the second greatest 'leakage' is the 71% of the A-Level cohort (133 900) who achieve at least one A-Level pass but not in a STEM subject;
- that not all young people with STEM A-Levels will go on to study STEM subjects in HE;
- that some gains could be made in increasing the conversion rates from STEM A-Level subjects into STEM subjects at HE, although these rates are currently very high for those with STEM A-Levels;
- that the real challenge is to get more young people further down the system studying STEM in the first place;
- that more could be done to influence the subject choice of young women in those areas where they are under-represented (physics, chemistry, mathematics, engineering, computing science).

7. Reconceptualising the research: issues for resolution

7.1 In many ways the data analysis and literature review have raised more questions than they have answered. It is clear from research and other reports that we know good practice when we see it, and it is equally clear from studies such as PISA[14] and TIMSS[15] that we know how we are doing in terms of international comparisons and domestic targets. What we appear not to have is comparative systematic, operational or cultural detail with respect to the FE sector when it comes to STEM and progression. The research for this report has identified the following six issues that highlight the challenges that we will need to address through ongoing work if we are to have a sound basis for action.

7.2 What we need to know is how the FE sector is doing in comparison to schools with respect to recruitment, enrolment, progression and achievement in STEM and STEM-related subjects at A-Level. The SE analysis points up the questions that arise with respect to FE learner awareness and advice, best learning environments, properly qualified staff and active learning models. This echoes many of the observations in the Leeds research review and analysis and the two Progression Reports for Mathematics and Science (NCETM and National Strategies). However, we do need a more sound evidence base as to origin, numbers and types of learners in FE and the pathways they take within the much more complicated subject choices available in colleges.

Issue 1: Disaggregation of statistics

The UK challenge for progression into STEM A-Levels and on into higher education is quite clear from the data above. However, in the context of the role of FE, the literature review and analysis make it

13 www.dius.gov.uk/publications/documents/science
14 OECD Programme for International Student Assessment
15 Trends in International Mathematics and Science Study

evident that, although there is much research on issues related to the set task, it is scant with respect to the issues of enrolment, retention and progression in STEM subjects in FE. In particular, most statistics relating to GCE and GCSE deal only with total entries across subjects and only differentiate between school, sixth form college, tertiary college and FE at a high level. Furthermore, in focusing on STEM subject areas there is no breakdown with regard to gender or ethnicity. Such data would inform future strategy.

The recent DIUS Report (January 2009) provides an LSC overview of what the FE system (including FE, work-based learning and adult and community) contributes to the STEM agenda, with some 95 000 learners in science and mathematics, 216 000 in engineering and manufacturing technologies. In addition 25% of science A-Levels and 24% of mathematics A-Levels are undertaken in the FE sector.

There is much interesting work being commissioned around the UK to unpack these high-level figures and to understand the differences between schools and the FE sector with respect to enrolment, internal progression, achievement and progression into HE. The work by EMCETT in the East Midlands is one such example, as is SLIM (Skills and Learning Intelligence Module) in the South West. The latter example is seeking to baseline, research, track, measure and monitor the demand and supply of young people involved with STEM.

Key Questions:

- What is the best way of making this data available from existing databases, or do we have to ask new questions of the Awarding Bodies and providers?
- How can we coordinate and collate the many attempts to capture and understand the data from across the regions?

Issue 2: FE subject descriptions

In the progression from school to university, the counting of STEM subjects is relatively easy and any exclusions, such as geography, are identified quickly. School-based STEM GCE and GCSE subjects are also easily identified. Similarly, at university, degrees regarded as STEM degrees are relatively easy to identify, including their association with essential pre-requisites for study, usually the school-based STEM subjects. However, in FE, the picture is far more complex. The National Database of Qualifications[16] lists over 400 L2/L3/L4 just for engineering in all its guises – and this is just one FE STEM area.

As Professor Sa'ad Medhat, Chief Executive of the New Engineering Foundation (NEF) commented"[17]

There is a general lack of clarity in what applied and vocational sciences mean to a number of educational institutions, government agencies and policy makers.

Key Questions:

- How should we define, map and 'tag' STEM and STEM-related qualifications?
- Could this become integrated with the FE two-part Employer Responsiveness Standard in some way, to act as a quality framework and standard for STEM and STEM-related provision?

[16] http//:www.accreditedqualifications.org
[17] 'Preparing for the Future' (NEF 2008)

- Do we need some form of ‘matrix curriculum’ description wherein STEM opportunities can be highlighted and linked – particularly given the evidence around ‘connectionism’ and the impact of STEM on progression?

Issue 3: FE organisation of learning

FE colleges vary enormously in how they arrange teaching. The NCETM’s report ‘The Organisation of Mathematics in Colleges[18], states: “In almost all colleges a division between ‘academic’ and ‘other’ mathematics was observed… This fragmentation into separate spheres of influence usually led to fragmentation in terms of staffing, with no single voice speaking for all mathematics provision”. As examples, Hartlepool College covers four STEM related areas: aerospace engineering, engineering operations and maintenance, construction and the built environment and electrical and mechanical engineering – each area encompassing seven A-Levels. Similarly, our case study example, Pendleton 6th Form College (Annex 3), offers biology, chemistry, physics, mathematics and further mathematics A-Levels, together with BTEC National Diplomas in applied science and a range of preparatory groups designed to both inspire and to provide connections in career and subject terms. These colleges are responding both to their diverse intake and to their local/regional economies. This flexible diversity will need to be mapped and understood if effective policy and funding strategies are to be formulated to support such provision.

Key Questions:

- How can we best describe the organisation of learning across FE to capture and highlight the contribution it makes to the STEM agenda (sectors, subjects, STEM)?
- How can these disparate organisational models be integrated into the broader STEM message and marketing?

Issue 4: FE participation

One of the big issues for FE is the flux and churn created by the decisions of learners across the academic year, which seem to be far removed from the linear pathways that the language of progression can sometimes assume. The work of Professor Phil Hodkinson, ex-Emeritus Professor of Lifelong Learning at Leeds University, challenges such linearity, highlighting the ‘folk theory’ of progression that underpins policy as not really based on the evidence[19]. This is also an area of significant gender difference.

Young people in FE seem not to follow prescribed pathways in the rational ways assumed by teaching schemes and careers advice and their actual decisions were strongly influenced by actions, events and circumstances that lay beyond their control. Bloomer and Hodkinson found in one of their research studies in early 2000, that 50% of their sample was not studying in September what they had chosen the previous May. These observations and findings raise issues both as to how to count people in FE and how to develop policies and programmes around progression that incorporate the way in which FE learners actually behave. The Ofsted Good Practice in post-16 Science report also highlights a lack of clarity with respect to progression routes as a feature of poor provision.

[18] NCETM 2008

[19] John Killeen Memorial Lecture, 16 October 2008

Key Questions:

- Can the new *Information Authority* set up under the aegis of the FE System Data Programme provide the beginnings of the solution through its DIUS-chaired Managing Information Across Partners[20] (MIAP) programme development?
- What is the expected uptake of Unique Learner Numbers and, allied to Common Data Definitions, will this begin to enable analysts to access the aggregated data with respect to learner pathways and achievements in FE?
- Can the Post-16 STEM Programme be helpful in joining up the proposed work on definitions and organisation of STEM with the emerging 'common data definitions' being developed by MIAP?
- Would it be helpful to initiate a study that tracks backwards learners described as successful inputs in HE terms (FE Access to HE Course, HE STEM Foundation Year and learners from those backgrounds on HE STEM courses)? This would enable their learning lives to be revealed and good practice modelled and codified.

Issue 5: FE and the policy landscape

There is some evidence in the research literature, particularly TLRP[21], 'Challenges and Change in Further Education', that policies around performance and funding may be impacting on the provision and delivery of STEM in FE. The Public Service Agreement target for the learner success rate in FE colleges was set at 76% for 2008 and 80% for 2011, plus work-based learning at 65% for 2008/09. Individual colleges develop their own targets in line with these national targets under guidance from the LSC and other local stakeholders. However, these targets are generic and, as a result, can be achieved at the same time as the number of achievements for L2/L3 STEM diminishes. There is no curriculum entitlement to STEM subjects in the FE system and no requirement to preserve provision.

There is an element of perverse incentive in this, allied to the fierce competition for customers and equally fierce competition for suitably qualified staff. Despite the LSC's Framework for Excellence (FfE)[22] emphasis on high quality provision and responsiveness to learners and to sector employers, the other performance indicators are qualification success rates, inspections and finance, which could lead colleges to invest in, say, sports and forensic science rather than the priority areas. The recent GHK review of the Framework for Excellence (2008)[23] for National LSC would argue that FfE presents a relatively robust picture, albeit with some small evidence from stakeholders with respect to perverse incentives and an emerging need to exclude or adapt some Performance Indicators on contextual grounds.

However, Professor Sa'ad Medhat (NEF) sees evidence here for the need for better coordination of STEM programmes and funding, as does the STEM Programme Report of Sir Alan Wilson (2006). In full-blooded terms the NEF report 'Preparing for the Future' argues that:

The distinction and demarcation between adult learning, apprenticeships and vocational education provision lacks clarity, and therefore, defining clear criteria for performance and, indeed, investment strategies for each of these provision categories has become confused and lacked impact and determination.

[20] Managing Information Across Partners www.miap.gov.uk
[21] Teaching and Learning Research Programme www.tlrp.org
[22] http://ffe.lsc.gov.uk/ffe/
[23] http://ffe.lsc.gov.uk/GHK+Consulting+Ltd+Independent+Review+of+Framework+for+Excellence.htm

Either way, research should be established to determine whether or not the impact of the new performance and funding regime in FE has been deleterious to STEM development in particular, in terms of investment, appropriately responsive course development and staff recruitment in shortage areas.

Key Questions:

- Is there evidence from the field that decisions have had to be made in the light of the Framework for Excellence that has resulted in less or worse STEM provision?
- Would a selective programme of interactive interviews with Principals, Curriculum Managers (157 Group, Knowledge Transfer Pathfinders and smaller General FE Colleges) and LSC on the development and provision of STEM in their colleges enable an understanding of the impact of Framework for Excellence to be established?
- Would such a survey be useful in developing informed thinking around targeted funding and investment, with the possible development of ‘accredited’ STEM centres on a par with the FE Knowledge Transfer Pathfinders?

Issue 6: Empowering the college – tools for change

Given the focus on self-assessment and quality improvement in the FE sector, it would seem strategically sensible to develop appropriate STEM-specific audit and strategy tools that would enable teachers, curriculum teams and managers to map, join up and develop a critical mass approach to STEM subjects and their inter-connections, expressed through a STEMsmart Action Plan. The aim would be to improve quality, increase throughput, extend external links and raise achievement, through these developmental actions and through integration with the national promotion of STEM through the Post-16 STEM Programme Team.

Key Question:

- Would teachers and managers in FE welcome such a development?
- Are there techniques and tools out there?

7.3 Clearly, the six strategic issues above are underpinned by a number of specific questions that attempt to understand why things happen in the way they do. The following have been highlighted in the Leeds Research Review and work on A-Levels generated by the Post-16 STEM Programme Team. They are not definitive but do indicate the detail which will be needed to respond to the STEM challenge as laid down by Professor John Holman:

- Why do STEM learners choose to study in FE rather than school?
- Are there differences in approach to the teaching of STEM subjects in school, sixth form colleges and FE colleges?
- Is there evidence that particular approaches are more successful in particular settings?
- Is there evidence that some approaches are more successful for some categories of learner (based on gender, ethnicity etc.)?
- To what extent does policy influence teaching approaches and, potentially, impact on the experiences of STEM learners in FE?
- How are the gaps in knowledge between different curriculum levels (identified by Roberts Review 2002, Sutherland and Dewhurst 1999, Lee et al 2007) best remedied to ensure that learners can make effective decisions in the STEM arena?

- STEM learners in general are less likely to progress on to the second year of their course; those on computer sciences, mechanical or electronic engineering are less likely to progress than other STEM learners – why?
- AS-Level entries and pass rates.
- Level 3 vocational subject entries and pass rates.
- The trends in high grade pass rates at A, AS and in vocational subjects.
- A, AS and vocational subject entries and pass rates in relation to gender, ethnicity and (if possible) socio-economic class.
- The “fit” of A-Level choices in relation to where employment opportunities will be in five or 10 years.
- Learners’ perception of what constitutes “hard” or “easy” subjects.

8. Meeting the challenges

8.1 It is clear from the findings and reviews above that there is much to be done in terms of establishing a clear picture as to progression from GCSE to A-Level and beyond in STEM and related subjects within the FE sector. However, there were a number of key messages with respect to teaching, learners and uptake which offer ways forward. It is worth repeating the conclusion of the 2007 McKinsey study, ‘How the world’s best performing school systems come out on top’:

> *Above all, the top performing systems demonstrate that the quality of an education system ultimately depends on the quality of its teachers.*

8.2 **Key Message 1: Organised and Purposeful Teaching**

The central message of the impact of enthusiastic, expert and well organised and resourced teaching shines through the very varied research literature. Both the NCETM report, ‘Factors Influencing Progression to A-Level Mathematics’, and the Secondary National Strategy Report, ‘Progression to post-16 science: interim report’ emphasise the common good practice features associated with successful STEM progression within and beyond institutions including:

- curriculum continuity and planning within a dedicated team
- lively, experiential and specialist teaching
- challenge and enrichment in teaching
- knowledge of learners, personalised learning and assessment
- good resourcing and ‘marketing’ of the subject
- connections with other subjects, careers and society
- whole organisation and senior management support
- integrated and consistent CPD for teachers
- increasing impact of Subject Learning Coaches.

This evidence is reinforced by the findings of Ofsted[24] and of the NCETM in ‘Mathematics Matters’, a report on what constitutes effective teaching and learning in mathematics.

[24] Identifying good practice: a survey of post-16 science in colleges and schools (Ofsted, January 2008)
Mathematics: Understanding the Score (Ofsted September 2008)

The same findings with respect to positive indicators and outcomes are reflected in a number of TLRP research studies in the sixth form college and FE sectors. These are demonstrated by the case study of Pendleton College, Salford, which shows that a similar mixture of factors - a dedicated team, good pedagogy, enrichment, preparation courses, external links and effective inputs from the Subject Learning Coach - can transform enrolment and achievement by significant percentages. (Annex 3)

Another aspect to this is what kind of learning will be developing into the 21st century. Although much of the work of Professor Stephen Heppell[25]. has been school-focused through UltraLab, it parallels similar thinking at MIT in the USA, Bob Fryer's early 1997 report 'Learning in the 21st Century' and analysis of the impact of Web.2. on learning trends. As a reflective practioner's tool, Professor Heppell developed his 'Learnometer' which provokes questions as to the design and delivery of education in infrastructural and educational terms.

Trends from…to

20th Century	21st Century
Conforming	Igenious
Stable	Agile
Quality controlled	Quality assured
Subject based	Project based
Delivered wisdom	User generated content
One size fits all	Personalisation
Individualised	Collaborative
National	Global
One to many	Peer to peer
Interactive	Participative
Curriculum centred	Learner centred
Retaining	Critiquing
Teaching	Learning
Short time blocks	Longer/flexible

It would not be unexpected if STEM subjects led the way in this thinking. The E-learning Programme[26], which forms part of the LSIS Teaching and Learning Programme, may provide opportunities for providers to develop e-learning solutions to progression in STEM.

8.3 **Key Message 2: Learners' own experience, perception, choices and aspirations**

There is some evidence that the more rigid FE structures[27] may inhibit good, formative teaching and assessment. Studies of persistence and choices (Martinez and Munday 1998 and Hodkinson 2007) underline the importance in FE of learners' own experiences and perceptions in the choices they make if

Evaluating mathematics provision for 14-19 year olds (Ofsted May 2006)
[25] www.heppell.net
[26] http://teachingandlearning.qia.org.uk/tlp/elearning/index.html
[27] Challenge and Change in Further Education: A commentary by the Teaching and Learning Research Programme (May 2008)

not satisfied or engaged. Both the SE analysis and the EMCETT survey of the East Midlands FE found some evidence of poor progression from Foundation through to Level 3, compounded perhaps by some teachers of STEM subjects expressing dissatisfaction with learner ability post Level 2.

This research (Hernandez-Martinez et al 2008 'Mathematics students' aspirations for higher education: class, ethnicity and gender') focused on the HE aspirations of FE mathematics learners. It is an important pointer as to the need to align teaching and learning strategies in FE with what the research calls the 'repertoire style' of learners. Their drivers varied across 'becoming successful', 'personal satisfaction', 'vocational need' and 'idealism'. Interestingly, some groups in the sample fell predominantly into one category, such as Black and Asian into 'becoming successful'.

Clearly the language of personalised learning and support in secondary education needs to be factored into the FE experience and support the Hodkinson view of progression in FE. This might include extra support in mathematics, use of mathematics, applied science, gender-specific initiatives and 'mixing and matching' STEM subjects based on learners understanding their value in the market place – the connectionist model described by Manchester University in their 'Widening Participation' study for the TLRP project[28].

8.4 **Key Message 3: Supporting teachers of STEM subjects in FE**

Lifelong Learning UK (LLUK)[29], the Sector Skills Council responsible for the professional development of FE staff, is currently taking forward crucial work on STEM workforce development in FE. Its analysis of Staff Individualised Records indicates that STEM staff have remained at 18-19% of the total teaching staff over the period 2002-2006, although women only make up 39% of STEM staff. There are serious shortages in key areas such as science, engineering, ICT (specialist) and Skills for Life numeracy teachers.

This work is being done in close association with the 10 SSCs which are STEM focused and which align with some of the earlier comments regarding the organisation of learning in FE:

- SEMTA (Science, Engineering and Manufacturing Technologies);
- COGENT (Chemicals, Pharmaceuticals, Nuclear, Oil & Gas, Petroleum and Polymers);
- EU-Skills(Energy and Utility Skills);
- e-skills (IT and Telecoms);
- Financial Services Skills Council (Mathematics);
- Construction Skills;
- Summit Skills (Building Services/Engineering);
- Improve (Food and drink manufacturing and processing);
- Proskills (Building products, coatings, extractives, glass and printing);
- Skillset (Audiovisual Industries).

The themes emerging from analysis of these SSCs include:

- developing the capability of the workforce to deliver new qualifications;

[28] www.lta.education.manchester.ac.uk/TLRP
[29] www.lluk.org

- new forms of delivery of learning;
- quality and flexibility of delivery and the need to build the capacity of the FE sector in line with both the projected increase in learners and the rapidly developing knowledge base of STEM subjects.

This is a very large agenda for change and improvement and draws on the need for infrastructural investment, CPD developments supported by Subject Learning Coaches, and fundamental thinking around the nature and organisation of learning in the 21st century. LLUK recognises the potential role in this for the National Skills Academies and the Regional Development Agencies, all of whom have at least one STEM area as a priority. Alongside them, the Knowledge Transfer Pathfinder FE consortia are now beginning to operate in STEM sectors such as aerospace, marine, construction, financial and engineering sectors. This makes the concept of dual professionalism[30] for STEM teachers even more important and should loop back into a critical mass of improved teaching over time.

8.5 **Key Message 4: Increasing the uptake in STEM subjects at Levels 3 and 4**

This is the heart of the matter with respect to the whole STEM agenda. The Sainsbury Review, Innovation Nation and The Demand for Science, Engineering and Mathematics Skills reports all make clear that the UK's future is significantly based on maintaining a healthy knowledge-intensive economy, driven by STEM subjects and our capacity to innovate and be creative. Within this, the FE sector is expected to play a significant role in both educating and training and in providing Business Innovation Services to its economic hinterland of SMEs. In particular, the FE sector can seek to optimise the way in which it recruits, enrols, advises, teaches and enables young people, and, looking at the demographic projections, not so young people, in STEM and STEM-related subjects.

The literature on the reduction in uptake of STEM subjects is, in the words of the Leeds University research review, 'persuasive and authoritative'. The central message is worrying with report after report (Institute of Physics 2001; Roberts 2002; Stagg 2003; Royal Society 2007; Nuffield Review et al) describing declining or static take-up, certainly relative to the increase in post-16 numbers. Indeed, HEFCE (2005) identified STEM subjects as 'strategically important and vulnerable subjects' in terms of mismatch between supply and demand in these areas.

However, we are now at a point where this analysis is the point of departure. John Holman, in his 2008 address at the National Science Learning Centre, University of York, in his role as National STEM Director, outlined the necessary ground-breaking strategies for stopping the decline and for moving forward. The detail of this has been outlined in 3.3/3.4 of this report and the examples below are either strategic examples or specific examples of the multiple ways forward that are being forged:

Ways forward:

- the systematic, multi-strand programme being driven forward by the STEM Management Board (3.3);
- the creation by LSIS of the Post-16 STEM Programme as part of the Teaching and Learning Programme. This is the only post-16 programme focused on STEM and its aims are to inspire change at both the individual and organisational levels in the FE sector;
- the growing influence and impact of STEM Subject Learning Coaches and STEMNET Science and Engineering Ambassadors (SEAs) across the education world;
- the continuing and growing impact of networks such as STEMNET and the Further Mathematics Network in engaging with young people;

[30] *Dual Professionalism:* maintaining a professional standard in their area of expertise together with maintaining excellence in their teaching practice *(Institute for Learning, 2007).*

- the STEM Coordination Framework proposed by Sir Alan Wilson in his earlier report and being taken forward by John Holman, which will bring much needed coherence to the sector. It will organise the 200+ STEM initiatives into Action Programmes targeted at recruitment, CPD, curriculum enrichment and enhancement, formal curriculum reform and capacity building at local, regional and national levels;
- the growing understanding of and use of applied mathematics and science and use of mathematics in widening interest, supporting persistence and progression and supporting learner achievement (Nuffield Review 2008/TLRP University of Manchester);
- the work of the Regional Development Agencies in supporting and prioritising the STEM agenda, such as One North East's STEM Skills Strategy, which is focused on local innovative approaches to increasing participation and attainment;
- the growing initiatives, products and services being developed by the National Skills Academies, in particular nuclear, construction, financial, manufacturing, process and food and drink manufacturing;
- initiatives such as the Design and Technology Association joining the 5-19 STEM Programme Board and the development of science-based CPD for D&T teachers. Both these initiatives begin the process of giving D&T a voice alongside other professional associations and helps the development of pathways other than science and mathematics into engineering – all part of the step change being sought;
- the Engineering and Technology Board's 'Engineers Make it Happen' campaign;
- organisations that are particularly focused on the participation and progression of women in STEM at all levels, such as Women into Science Engineering and Construction (WISE), Women's Engineering Society (WES) and UKRC for women in STEM.

This indicative list is formidable in both its scope and its granularity. It gives a flavour of the energy in the STEM field, ranging from government to teachers, businesses to professional associations. The point that Professor John Holman makes with respect to the need for coherence and for agreed performance indicators is critical. It is clear from the review of research that we do not know enough about what is actually happening in the FE sector with respect to STEM recruitment, enrolment, teaching, progression and achievement. The research recommendations in section 7 provide a necessary starting point, as each one of these issues needs unpacking as well as 'mapping'. The main objective of this work is to change things for the better and to improve our supply of excited, creative, innovative and competent scientists, mathematicians, engineers and technologists.

The UK has a magnificent history of invention and it is worth ending on that note, drawing on Jenny Uglow's book, 'The Lunar Men' in which she describes the intertwined lives of Darwin, Boulton, Watt, Small, Keir, Whitehurst, Wedgewood and Priestley thus:

> *They felt the greatness of the cosmos and its limitless possibilities, the beauty of the infinitely small – the bud, the grain of quartz, the microscopic animalculae – and the grandeur of the vast, the thundering force of steam, the rolling clouds, the relentless flow of lava over aeons. They knew that knowledge was provisional, but they also understood that it brought power, and believed that this power should belong to us all. The legacy of the Lunar Men is with us still, in the making of the modern world, and in inspiring confidence with which all these friends, in their different ways, reached so eagerly for the moon.*

The National Centre for Excellence in the Teaching of Mathematics (NCETM), the National Science Learning Centre, the Royal Academy of Engineering and Tribal Education have combined their expertise to deliver the Post-16 STEM Programme as part of the LSIS Teaching and Learning Programme.

To read or contribute to the discussion and get involved in the activities of the Post-16 STEM Programme visit www.subjectlearningcoach.net or the Excellence Gateway at http://teachingandlearning.qia.org.uk/tlp/stem/index.html

