STEM REVIEW

the Science, Technology, Engineering, Maths Supply Chain

Hugh Smith

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A Review of the STEM Skills Supply Chain

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March 2007

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Introduction

Recent discussions have identified that there remains a shortage of quality graduates and postgraduates with appropriate IT and general STEM skills and experiences – a shortage that applies to all employment sectors where science, technology, engineering and maths (STEM) graduates are at a premium.[1]

Professor Sir Gareth Roberts addressed this issue in his report *SET for Success*[2] in April 2002 and the Government responded positively in subsequent funding and other initiatives. In early 2004 Professor Adrian Smith issued his report into post-14 mathematics education, *Making Mathematics Count.*[3]

There has been a range of responses by some Government departments, employers and professional bodies, and much of the work that has followed Roberts is now gathered together and structured as an action plan in the DfES/DTI *STEM Programme Report* .[4] Other valuable insights have, for example, been provided by The Royal Society's report *A degree of concern?* [5] and the Engineering and Technology Board's *Engineering UK* series.[6] This report by the Council for Industry and Higher Education (CIHE) aims to provide a brief but systematic review of the actions taken by all parties to address the recommendations in the Robert's Review and what further might be done to take that agenda forward. Much of the report focuses on developments in England. The devolved administrations across the UK follow broadly similar principles in their approaches to these matters, while in some instances developing initiatives more appropriate to their own circumstances and strengths.

The report reviews at a general level what the various key players are doing, the impact of implementation of Roberts' recommendations, and what more detailed analysis of the STEM supply chain might be appropriate. The review considers how progress might best be directed in the future.

We much appreciate the advice and involvement of a wide range of people whose names are listed in Annex A. A draft of the report was discussed by leaders from businesses, academia and Government (see Annex B) at three separate events and we are most grateful for their insights, general endorsement of the conclusions we have drawn from the evidence presented and additional refinement to the recommendations.

We are particularly grateful to LogicaCMG and their Chief Executive, Dr Martin Read (a CIHE member), for the additional funding that has made this work possible.

I would like to thank Hugh Smith who has worked so assiduously to produce such a measured and balanced assessment. We were also indebted to the insights and support of Professor Sir Gareth Roberts who sadly died as we were finalising our work. We dedicate this report to him and can only marvel at his achievements in this and so many other areas.

Richard A Brown
Chief Executive

[1] LogicaCMG / CBI: *Building a Globally Competitive IT Services Industry – Report and Action Plan* (Oct 2006) http://www.logicacmg.com/r/350233078/page/400004490

[2] Roberts Review: Sir Gareth Roberts, *SET for success: The supply of people with science, technology, engineering and mathematics skills* (April 2002)

[3] Making Mathematics Count: the Report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education (February 2004) http://www.mathsinquiry.org.uk.

[4] DfES/DTI: *STEM Programme Report* (Oct 2006) http://www.dfes.gov.uk/hegateway/hereform/stem/programmereport.cfm

[5] Royal Society: *A degree of concern? UK first degrees in science, technology and mathematics* (October 2006) http://www.royalsoc.ac.uk/policy

[6] Engineering & Technology Board: *Engineering UK 2006*

Summary and recommendations

This report offers a view on how far the recommendations in the reports *SET for Success* (2002) by Professor Sir Gareth Roberts and *Making Mathematics Count* (2004) by Professor Adrian Smith have been implemented and what else might be done to develop the graduates and postgraduates who have the STEM skills that businesses need. Our review has been informed by the views of both Sir Gareth and Professor Smith and by many others whose names are listed in Annex A. We have also held focus group dinner or lunch discussions with Council members and others (listed in Annex B) on a draft of this report. We are most grateful to all who have given us their views. We hope that our findings are evidence-based and as objective as any report on this important theme can be.

Our conclusions are:

- Since 2002 the numbers of STEM graduates has increased considerably (except in engineering) but the number of those taking STEM A-levels has declined, with considerable falls in those taking mathematics, physics and computer sciences. Further back in the education supply chain numbers are driven largely by cohort size. However, students taking GCSE in science and mathematics have increased whilst those taking design, technology, IT and ICT have fallen so that overall the STM numbers have shown virtually no increase;
- The numbers of postgraduates have also increased and the DTI/OSI has been successful at meeting the main proposals in the reports including through increasing stipends and investing in research and career guidance; while the high percentage (39%) of STEM postgraduates from overseas helps sustain STEM departments, this could leave UK businesses vulnerable if such students returned home;
- The knowledge-intensive services and creative industries as well as manufacturing sectors rely on STEM graduates and postgraduates;
- Finding qualified teachers to teach STEM subjects is vital; students need above all to be inspired by those who know their subject and can bring it to life; too many science classes are still taken by teachers working outside their own subject specialism; there have been increases in the number of graduates in STEM subjects who go on to teacher training (overall by 31%, and by 74% in physics) and the “golden hellos” of up to £10,000 together with national drives on this issue are having an effect; the momentum needs to be sustained as the overall task to increase numbers from a small base is huge; gender and ethnic imbalances including at regional level also need to be addressed;
- There has been an increase in teaching assistants and in students and recent graduates undertaking paid work experience in the classroom and this has added to overall teaching resources; it has also bolstered the perceived attractiveness of the profession and developed a pipeline of younger STEM subject teachers;
- There has been less progress in arranging for existing teachers to develop their CPD, and schools Governors and headteachers need to take greater responsibility for this area;
- There has been inadequate progress in investing in school laboratories and the Government needs to take this issue more seriously if students are to be enabled to work on equipment relevant for a future in work at technician level or progression to higher education;
- A range of other Government-funded initiatives such as SETNET and TDA’s Student Associates Scheme have also had an impact in raising awareness; the example of Computer Clubs for Girls might be emulated as the growth in female participation in higher education allied to their choice of the bio-sciences rather than other STEM subjects means that participation levels in STEM overall will always struggle without increased female participation; there needs to be a focus on 10-14 year olds;
- The requirement on school children in England to focus their studies after the age of 16 and exclude themselves from a broadly based curriculum can excessively narrow choice; maths underpins STEM subjects and more needs to be done to maintain this subject at 10-14 years of age;
- Employer involvement in the development and delivery of the STEM curriculum is increasing in schools, colleges and universities; but more coherent messages about the career benefits which the study of STEM subjects can offer need to be conveyed (including from the professional bodies) and more placements and work experience opportunities need to be offered;

- The curriculum needs to be made more exciting, real and relevant, and employers have an important role to play in this;
- Career guidance remains patchy across schools and universities; employers and professional bodies could do more to support such services; good information for secondary students about the attractiveness of STEM careers is in short supply; we need support for initiatives such as the Science Council's *Careers from Science* website;
- Maintaining and investing in university STEM Departments is high cost; some universities will not be able to afford the investment; some further closures and concentration is therefore inevitable and Ministers should recognise this – especially if the additional Government funds are not forthcoming to support the investment;
- The STEM supply chain can be analysed in business process terms; a few percentage point changes in decisions at every join in the process can reduce leakages and lead to increased output of STEM graduates at the end of the pipeline;
- The establishment of a STEM Director and a Government Chief Advisor for Mathematics has given a focus and urgency to addressing the issues; but some immediate actions are needed given that the supply chain of STEM graduates remains leaky at all the decision-making joints and the supply emerging is inadequate in key areas to meet business needs.

Our recommendations are that:

- The Governments and Assemblies across the UK should agree with the professional bodies what the statistics are telling us about the numbers studying each and every STEM subject; The DfES should lead on this; actions (including those by the higher education funding councils) need to reflect the evidence and focus on where serious problems remain (as in computing and IT);
- The Government (DfES) should do more to publicise and promote what is happening to evolve the curriculum (eg with a science diploma) but also continuously review and report to Parliament on how the curriculum in England can keep open the subject options for students; the post-16 curriculum in England must retain breadth while still allowing those who wish to pursue STEM subjects in depth to do so;
- Employers and professional bodies should work to highlight the message to students that STEM subjects can lead to very good career prospects, with a potential earnings premium;
- The National STEM Director should urgently consider what early levers can be pulled to radically improve the STEM skills supply chain; he should not rule out such ideas as funding incentives for passing STEM A-levels, Government bursaries for STEM students, or weighting STEM subjects in UCAS points; he should report publicly to Ministers on his recommendations;
- The publication of post-16 science progression indicators in school performance tables is strongly recommended so that students and parents can clearly assess the success of different schools in encouraging students to study STEM post-16;
- The Government needs to consider incentives to encourage teachers to take up CPD opportunities, including bursaries to cover fees and supply costs; greater partnerships between schools should be encouraged including the greater use of e-learning delivery and sharing of resources;
- The STEM Director should consider what additional incentives are needed to attract and retain quality STEM teachers; he should report publicly his advice to Ministers;
- The importance of STEM graduates and postgraduates to the UK economy should be better recognised by the Home Office and DWP when decisions are made about granting UK citizenship;
- The Government Chief Scientist, working with the National STEM Director should call together the engineering and science professional bodies and encourage them better to coordinate their work to emphasise the attractions of STEM subjects and careers and offer greater resource support for teaching;
- The professional bodies should consider combining their bursaries so that they are widely available and well promoted; the Institute of Physics should initiate the action on this;
- The Government should ensure the effectiveness of the newly established STEM Programme through proper funding and support for its strategic work; the STEM Director should make publicly available twice-yearly reports to Ministers which should include the views and actions being taken by the Government's Chief Advisor for Mathematics.

A review of the STEM skills supply chain

The Roberts Review

1. The Roberts Review sought to address the issue of the balance between supply and demand of high quality scientists and engineers as a key element of the UK's future research and development (R&D) and innovation performance.

2. The Review acknowledged that the number of students studying for scientific and technical qualifications was relatively large in comparison with other countries and was growing. However it noted that the growth was chiefly due to increases in the biological sciences and IT which masked a downward trend in numbers studying mathematics, engineering and the physical sciences.

3. The Review also noted a strong level of demand for graduates and postgraduates in the more numerical subjects – a demand that came from a range of employment sectors extending well beyond the science-intensive fields into, for example, financial services and ICT. In parallel with this was a declining attractiveness of PhD study to first degree graduates.

4. Over thirty recommendations were made in the Review, and it is these that are explored here. They were mainly targeted at the Government, funding bodies, HEIs, the Research Councils and employers. The recommendations were also grouped into the stages of school, undergraduate and postgraduate learning and employment.

5. The recommendations have been the subject of considerable activity by a wide range of players in the intervening years with recent steps such as those set in train by the STEM Programme Review intended to bring added focus to the wide range of effort being made. Nevertheless there remains a consensus that people with STEM skills of a suitable quality remain in short supply, whether for roles in academic research, in businesses or in teaching.

Trends in STEM qualifications since Roberts – numbers and quality

6. STEM skills supply can be measured in a variety of ways – a factor which can in fact cloud the central issues – and a number of angles are taken here. UCAS data provide a picture of university application levels (Table 1). These data have been used in HEFCE's work with DfES to support strategically important and vulnerable subjects – a category which includes STEM subjects as well as a number of others such as modern foreign languages (the latest UCAS figures for 2007 show an increase in applications that we hope will be converted into students taking and then completing STEM courses).

Table 1: **Applications for degree courses – strategic & vulnerable subjects, since Roberts**

	2002/03	2005/06	Change %
Mathematics & Computer Science	34,136	26,250	-23%
Physical Sciences (all)	13,635	14,384	+5%
Physics	3,099	3,190	+3%
Chemistry	2,860	3,174	+11%
Biological Sciences	31,874	35,614	+12%
Total STEM	**85,604**	**82,612**	**-3%**

Source: HEFCE Report to the Secretary of State for Education and Skills: *HEFCE's Support for Strategically Important and Vulnerable Subjects;* (Oct 2006), Data from UCAS website http://www.ucas.ac.uk/figures/ads.html#instsubj

7. It is recognised that whilst UCAS applications clearly bear a linkage through to final graduate outcomes, it provides an imprecise measure as UCAS covers applicants only for full-time study; applicants for part-time

or direct entry are thus excluded, and the data give no measure of students who decline offers, switch course or who do not complete their degree.

8. Graduate qualifications awarded are one key measure for which HESA data are typically used. At the level of subject area HESA show a broad growth in graduate output since the Roberts Review at both first degree and postgraduate degree across the STEM subject areas as Table 2 shows:

Table 2: Graduate qualifications – Output (UK, full- & part-time) over 10 years, and since Roberts

	1994/95	**2001/02**	**2004/05**	**Change % 1995-2005**	**Change % 2002-2005**
Mathematical Sciences	4,069	4,130	5,270	+1%	+28%
Computer Science	8,274	14,300	20,095	+73%	+41%
Physical Sciences	13,440	12,415	12,530	-8%	+1%
Engineering & Technology	22,083	20,285	19,575	-8%	-4%
Biological Sciences	12,378	18,495	27,200	+49%	+47%
All STEM	***60,244***	***69,625***	***84,670***	**+16%**	**+22%**
All Subjects	**237,798**	**274,440**	**306,365**	**+29%**	**+12%**

Source: HESA: *HE Qualifications Obtained in the UK by Mode of Study, Domicile, Gender and Subject Area Table 14*

There have been some amendments during that period in the methodology used by HESA in assembling these data and in returning the figures for the Open University, so that the 1994/95 data are likely to be a slight underestimate. Nonetheless the picture since the Roberts Review is one of growth in the numbers qualifying with STEM degrees, as grouped by subject area. However work commissioned by the Royal Society and the Office of Science and Innovation allows a valuable disaggregation of HESA data below the level of subject area for the 1994/95 to 2004/05 period. This shows that despite fluctuations over the period;

- the numbers graduating in biology, physics and mathematics have been relatively stable;
- much of the apparent rise particularly in mathematics is a consequence of the way that HESA has classified students on dual honours courses;
- within the biological sciences group, the proportion studying biology as a subject has fallen from 31% to 17%, as options such as sports science and psychology have grown in popularity;
- numbers graduating in chemistry have shown a substantial decline.

9. The make-up of the graduating population is earlier reflected in their pattern of application for degree courses, and disaggregating the applications data from Table 1 using a similar approach to the Royal Society's work above gives the split shown in Table 3. This provides a measure of the relative levels of interest shown in the various STEM subjects by students as they complete their secondary education.

Table 3: **Applications for degree courses, since Roberts**

	2002/03	**2005/06**	**Change**
Mathematics & Computer Science	34,136	26,250	-7,886
within which: *Mathematics*	3,325	5,063	+1,738
Computer Science	19,227	13,650	-5,577
Information Systems	5,396	2,849	-2,547
Physical Sciences (all)	13,635	14,384	+749
within which: *Forensic & Archaeological Science*	822	1,522	+700
Biological Sciences	31,874	35,614	+3,740
within which: *Biology*	4,714	4,313	-401
Molecular Biology, Biophysics & Biochemistry	2,030	1,920	-110
Sports Science	7,959	9,924	+1,965
Psychology	13,615	15,847	+2,232

Source: HEFCE Report to the Secretary of State for Education and Skills: *HEFCE's Support for Strategically Important and Vulnerable Subjects;* (Oct 2006)

10. After some years of significant growth in the higher education initial participation rate this has now moderated although it is unclear whether a new trend has yet been established.[7] Immediately prior to Roberts the participation rate had built to 41%. It grew to 43% in 2002/03 and has subsequently fallen back to 42% for the two most recent years. Whether this is a hesitation in an otherwise upward trend, or is recognition that a peak has been passed will become clear in coming years. The demographic projections, however, for the 18-20 year old population show a marked decline after peaking in 2010/11 at 2.45 million, falling to around 2.1 million by 2020/21. The fall is less marked in those social groups in which progression to higher education is more prevalent, and in consequence the impact on higher education numbers may be mitigated, though at the expense of the profile of the lower socio-economic groups in higher education.

11. This longer term increase in overall higher education participation has seen growth of graduating numbers in some STEM subject areas but declines in others, some of which are shown to be more significant than the headline figures suggest. A number of reasons for these issues with the STEM subjects are generally given:

    - The STEM subject degree programmes are seen as harder to get into than many of the alternatives. The fact that many of them require a mathematics A-level – itself a subject under some pressure in uptake at secondary level – tends further to hold back enrolment;

    - The STEM department closures that occur gain a disproportionate measure of publicity, influencing students, parents and careers staff in a way that can lead them to favour a field of study that appears more sustainable to them. This may serve to paint a picture of declining prospects for STEM skills in the UK;

    - There is some evidence that universities are promoting STEM subjects less vigorously than others, except to overseas students. This may be driven by the situation where laboratory-based subjects have proved more expensive to teach than the funding provided through the current funding regime;

    - It is also noted that the high rate of growth in numbers studying medicine (70% between 1997 and 2004) acts to draw off a significant proportion of higher quality applicants who would otherwise be qualified for STEM degree courses.

[7] Summarised in *Engineering UK 2006*, Engineering & Technology Board (in preparation)

Other issues of STEM graduate quality and gender balance

12. Within the choice of degree subject many programmes offer a range of options or modules, and the process by which a student makes their selection may itself affect the broader outcomes. Where employment prospects are a key criterion for the student, the emphasis will be on achieving at least an upper 2nd class degree, and module selection can influence this as some modules are seen as easier than others. Conversely some employers, particularly those requiring a strong STEM subject capability in their recruits, regard a ‘pure’ subject as more challenging than some modular alternatives. The scope for gaining a degree through a step-by-step modular process can result in a grasp of the topic that is perceived by the employer as somewhat selective.

13. Mathematics is a case in point. It is a degree which is attractive to many employers, and it provides a good base for an expanding range of service industry careers. It is also seen as a good predictor of longer-term career success. However, for employers who require the mathematical skills for application in strongly quantitative work, some modular programmes will be of lower value. These roles demand a degree that has included the advanced mathematics of, for example, use of calculus and manipulation of higher statistical functions. Where the student’s emphasis on these topics has been reduced by specific module selection, or where they are covered early in the course, the quality of understanding may hamper effectiveness in the job, although the overall class of degree may be adequate. The same is true where mathematics options are shunned by students taking other STEM subjects.

14. Gender balance has been acknowledged as an issue across the STEM subjects at all levels for a considerable time, with much lower levels of female participation in some areas, and a range of initiatives have sought to address it. Within engineering and technology subjects, the 2005 level of female participation was 15%. In other subjects the figures were computer science 24%; mathematics 38%; physical sciences 41%; biological sciences 64%. These levels have been relatively static over a number of years which suggests that attempts to boost female participation in the STEM subject area is a topic which could usefully be reviewed.

Trends in the secondary school STEM pipeline since Roberts

15. A satisfactory supply of degree-qualified people in the STEM subjects is dependent on the numbers studying the sciences and mathematics across the range of secondary qualifications – A-levels, Scottish Highers, Advanced VCEs, vocational A-levels, International Baccalaureate and so on. This pipeline is therefore an important one, in terms both of the inclination and interest of its students to pursue the STEM subjects and of their level of attainment. Trends in the pipeline were explored by Roberts and it was particularly noted that numbers choosing to study mathematics and the physical sciences at A-level were on a downward path, with a fall between 1991/92 and 1999/00 of 21% in physics and 9% in mathematics.

16. Data in Table 4 show that this decline has continued since Roberts. Whilst mathematics remains the subject in this grouping with the highest number of entries, its level of decline is substantial. Entries in 2005 were slightly up on 2004, although by just 17 students against an ‘all subjects’ increase of 15,447. There has also been a small increase in entries for further mathematics since Roberts, perhaps suggesting that quality and level of knowledge amongst those that do study the subject are being enhanced. Physics entries are also in marked decline, with a year-on-year fall of 512 entries in 2005. Over the longer 1995-2005 period there has been a decline in entries for all of these subjects except for a 5% growth in biology and 79% in design & technology. Computer science entries have almost halved since peaking in 2001.

Table 4: **A-level entrants in STEM subjects, since Roberts (examinations taken)**		
	Change 2001-2005	**Entrants 2005**
Mathematics	-15%	46,034
Further Mathematics	+3%	5,192
Biology	+2%	45,662
Chemistry	-2.1%	33,164
Physics	-14%	24,094
Design & Technology	+17%	16,077
Computer Science	-47%	5,810
All STEM	**-7.5%**	**176,033**
All Subjects	**+1.4%**	**691,371**

Source: DfES: GCE A level examinations taken – schools and FE sector, England

17. Choice of subject at A-level or equivalent is influenced by a number of factors, uppermost of which may be the appeal of the subject to the student, thoughts about career intentions and prospects, and advice from the school. Roberts explored and made recommendations about each of these elements, but schools themselves pay attention to targets including their success in securing A-level enrolments and the achievement of good grades. It is these criteria that affect their ranking in league tables. They may be inclined therefore to advise a student to drop a subject rather than to enter an examination which he or she is unlikely to pass. When students see this happening in a subject such as mathematics, it gains a reputation as a difficult subject, and some take an alternative option about which they are more confident. The school may do little to persuade them otherwise. The Government's *Science & Innovation Investment Framework 2004-2014 – Next Steps (2006)*[14] report flagged the option of introducing a post-16 science progression indicator to school performance tables, and its implementation would provide valuable pressure towards correcting the misconceptions that develop.

18. As with some degree structures, an increase in the modular approach of the A-level leads to the accumulation of a breadth of knowledge by the student but which over a period can result in their subject familiarity in some topics being diluted by the time of their higher education entry. As mathematics is a precursor for most STEM pathways at degree level, its decline in popularity means that higher education applications in the STEM area suffer, whilst modularity can mean that first-year university science is required to provide a level of remediation that slows the progress of the degree programme itself.

19. Looking further back in the STEM skills pipeline, data indicate that – whilst largely an effect of cohort size – the trends in candidate numbers for GSCE science subjects (Table 5) appear at present to be somewhat more positive. The impact of the 2006/07 changes to the GSCE curriculum have yet to take effect on these figures, but the trend is upward for candidates for the sciences and mathematics. However, this has been largely counteracted by reductions in the design, technology and IT areas. The combined effect is that growth across the STM subjects has lagged behind the rate of increase in candidates for all subjects at GCSE. The key impact for STEM skills supply to the employment marketplace subsequently depends on the rate at which students convert from GCSE to sciences at A-level and then through to their choice of degree.

Table 5: GCSE candidates in science, technology and mathematics subjects since Roberts (UK; all ages)			
	2002	**2006**	**Change %**
Mathematics	709,027	750,570	+5.9%
Biology	49,171	60,082	+22.2%
Chemistry	47,068	56,764	+20.6%
Physics	46,511	56,035	+20.5%
Biological Sciences	31,874	35,614	+12%
Total Sciences and Mathematics	**851,777**	**923,451**	**+8.4%**
Design & Technology	433,594	371,672	-14.3%
IT and ICT	116,033	109,601	-5.5%
All STM subjects	**1,401,404**	**1.404,724**	**+0.2%**
All subjects at GCSE	**5,662,382**	**5,752,152**	**+1.5%**

Source: Joint Council for General Qualifications, http://www.jcq.org.uk/press_releases/results/index.cfm

20. From a broad range of sources, the longer-term trend across the secondary and higher education levels of STEM subjects appears to be one of decline in numbers. There have been recent reversals in some subjects since Roberts, but the issue remains whether these are real shifts or are in part a reflection of changed data collection practices, and whether they will be maintained into the future.

Actions to implement the Roberts recommendations

21. The Roberts Review made recommendations in five main groupings:

- Schools and Further Education
- Higher Education
- Postgraduate Education
- Higher Education employment
- Research & development employment

Responses to the recommendations for Government, which formed the greatest in number, were made initially in *Investing in Innovation: a strategy for Science, Engineering and Technology* [8] and then in *Science & Innovation Investment Framework 2004-2014*.[9] The *STEM Mapping Review* [10] identified 478 initiatives in the STEM area being taken by DfES, other government departments and external bodies. Of these, 85 were initiatives that addressed the Roberts recommendations. The work that followed the Roberts review has recently been drawn together in the *STEM Project Report* [11] which provides a good basis for reviewing the progress.

22. In respect of schools, Roberts dealt with primary and secondary levels, making recommendations for both of these to address issues such as teacher recruitment and supply, teacher professional development, the curriculum and careers advice.

[8] HM Treasury/DTI/DfES: *Investing in Innovation A strategy for science, engineering and technology* (Jul 2002)

[9] HM Treasury, Science and innovation investment framework 2004-2014 (Jul 2004)

[10] DfES, Science, Technology, Engineering and Maths (STEM) Mapping Review (Aug 2004)

[11] DfES: The Science, Technology, Engineering, and Mathematics Programme Report (Oct 2006)

Teacher numbers in STEM subjects

23. Since Roberts the focus of STEM teacher recruitment has been largely through the implementation of financial incentives, particularly "golden hellos" and support with Initial Teacher Training (ITT) tuition fees. Differential bursaries are now payable so that a student training to teach in a priority subject area, which includes STEM, receives £9000 in place of the figure of £6000 for other subjects. Six-month enhancement courses have also been developed within teacher training for people intending to teach science or mathematics but who do not hold the necessary subject specific knowledge. During this training students receive an additional payment of £225 per week. Furthermore on completing the ITT course, a newly qualified teacher in a priority subject receives a "golden hello" payment of £5000 if teaching mathematics or science at secondary level, and £2500 in other subjects including ICT and design & technology. While the principle approach remains the same, different rates apply for example in Wales where in certain circumstances distinctive initiatives are followed.

24. Annual application levels for ITT courses[12] have grown significantly since Roberts, leading to a 31% increase in acceptances onto this training. Within this, acceptances onto sciences have risen between 2001 and 2005 by 44%, with 74% growth in physics and 58% in mathematics. These levels are still running short of target by 9%, and the goal set in the Government's response was to eliminate the undershoot by 2007/08. This would appear to be achievable on the current record.

25. However, there remains much ground to be covered in order to redress the balance between the different sciences in ITT acceptances. In principle the split required is one-third each way between physics, chemistry and biology to match to the demand of the three sciences in schools. For 2006 starters on ITT courses, the ratios are physics 20%, chemistry 30%, and biology 50%, and the trend is running marginally in against the desired three way split

Continuing Professional Development (CPD) for teachers

26. It is not clear that the Roberts recommendation that science teachers should be incentivised to undertake CPD has been implemented in a consistent way. Recommendations concerned with maximising the use of flexibility in remuneration to optimise the pay of STEM teachers have not progressed beyond the recruitment support and advanced skills schemes already mentioned. This is seen by many outside the immediate profession as the key to unlocking the STEM teacher supply and quality issues. However there is a broadly held view that "we are all teachers and should be paid similarly" and that the scope for differentials is currently limited.

27. Teachers' CPD was the subject of several recommendations in Roberts and a number of initiatives have been put in place in this area. While a different CPD framework applies in Wales for example, promotion within England of the Advanced Skills Teacher scheme has provided an element of the Fast Track scheme which develops teachers in the STEM areas. This can lead them to a career path on an improved salary spine, providing scope for teachers to advance their earnings through professional teaching without the necessity to shift into senior administrative and management roles. The National Centre for Excellence in the Teaching of Mathematics has come to play an important role in raising professional development of teachers in this discipline. Likewise the National Science Learning Centre and its regional network has established a substantial programme of development for science teachers through which delegates are brought together with other STEM teachers to develop relevant knowledge and skills. Collaboration with organisations such as the Wellcome Trust has supported this - a good supply of subject specific material is now available and the logistics are in place to accommodate the participants. However there are signs that uptake to date is lower than planned. This is due mostly to a reluctance by schools to allocate resources for the release of teachers for CPD activities and to the supply cover, indicating that there may be scope for the Government to consider incentives to encourage and support more action in this area.

28. Research Councils UK (RCUK) has worked with the Science Learning Centres to bring together researchers and teachers who can then be exposed to some of the latest research activities (eg a physics teacher hearing about astrophysics research). This scheme also provides an opportunity to explore whether a

[12] Graduate Teacher Training Registry: *Annual Statistical Report*; Reference No: GT14/05 UCAS (2006)

teacher of one science can be equipped to handle a parallel science topic with confidence (eg a biology teacher to explain biomathematics). RCUK's Researchers in Residence scheme, also supported by Wellcome, trains early-stage researchers to support teachers in schools and whilst chiefly geared to acting in a teaching assistant role this can also provide valuable professional development for the teacher.

Teacher support and laboratories

29. The provision of teaching/learning support assistants was given emphasis in the Roberts recommendations. One area beyond these formal arrangements in which STEM-sector employers have been active here is through participation in the SETNET Science & Engineering Ambassadors Scheme. This has become something of a flagship both for providing substantial numbers of young STEM professionals to offer voluntary classroom support to teachers, and for helping to enthuse young people about science and engineering careers. A parallel resource, the Teacher Development Agency's Student Associates Scheme, has now completed its third year of operation, as a broker between over 50 HEIs and their STEM students and schools. Degree and postgraduate students go into schools to explore the teaching profession as a careers option. They may often assist the teacher in the classroom and they receive payment of about £40 for each day. In the 2005/06 year the scheme exceeded the target of 7,500 student associates by a small margin, with about 2,000 of these being in science subjects.

30. The value of science technicians in supporting laboratory work was also emphasised in Roberts, and organisations like the Association for Science Education (ASE) have sought to support interest in this career. ASE's publication in 2004 of a career structure for science technicians[13] was a step to promote understanding and interest in this field. However science technicians are often grouped together with other teaching assistants in the way that they are managed, and their terms and conditions are often less good. Work by Newman College and the University of Leicester in developing a foundation degree for science technicians and ASE (funded by Gatsby Foundation) in creating an NVQ are further steps in this direction.

31. Roberts made recommendations in relation to the need to accelerate investment in school science laboratories, both as an essential in the ability to teach science well and as a route to enthusing young people about science subjects. Considerable funding has been made available by DfES for this, although how it is in fact spent is influenced by the specific preferences of school governing bodies. *Science & Innovation Investment Framework 2004-2014 – Next Steps (2006)*[14] reiterated the Government's commitment to achieve the 2010 target for this, but recent work done on behalf of the Royal Society of Chemistry[15] paints a muted picture. Over recent years less than 7% of school laboratories have been refurbished or rebuilt, and the rate appears to be falling. Moreover nearly 30% of those where this money had been invested were regarded as Good or Excellent. The DfES School Labs of the Future – Faraday Project – is now in place aiming to create a set of exemplar laboratories. It will be vital that the input of science-teaching professionals is sought and incorporated and combined with specialist architecture and design criteria to deliver solutions that (whilst attractive) are primarily effective in terms of practical usage for teachers and laboratory technicians. The recent report of The House of Lords Science and Technology Committee, *Science Teaching in Schools*[16], was critical of the shortfall in Government funding and some aspects of the approach to design in this area.

The Secondary curriculum and careers

32. Roberts made a number of recommendations about the secondary science curriculum and a new GCSE curriculum has been introduced from 2006, having been deferred by two years to allow proper

[13] The Association for Science Education (ASE): *Supporting Success: A Career Structure for Science Technicians in Schools and Colleges* (Jul 2004) http://www.ase.org.uk/careerstructure.php

[14] HM Treasury/DTI/DfES/Department of Health: *Science and Innovation Investment Framework 2004–2014: Next Steps* (Mar 2006)

[15] CLEAPSS: *Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools* (Oct 2006) http://www.rsc.org/images/Labsreport_tcm18-65943.pdf

[16] House of Lords Science and Technology Committee, 10th Report of Session 2005–06: *Science Teaching in Schools - Report with Evidence* (Nov 2006) http://www.publications.parliament.uk/pa/ld200506/ldselect/ldsctech/257/257.pdf

implementation following pressure from bodies such as the ASE. Early evidence suggests a positive effect in getting students engaged, with scope therefore to help raise the potential pool of students who may consider STEM at A-level. This will be further assisted if introduction of the new curriculum has the effect of shifting some of the 80% of students who currently take double science GCSE to some taking 21st Century Science and some taking three single sciences. The key will then be to support them in their decision-making over the 16-18 year transition.

33. More generally, STEM employers comment that the efforts to keep the secondary curriculum broad tends to counter the degree of specialisation that can lead to a good supply of graduates in the more specialist disciplines such as metallurgy. The perception is that in countries which do maintain a broad secondary curriculum, perhaps through baccalaureate systems, it is followed by a longer higher education programme – resulting in older graduates who have kept the breadth at secondary level and then specialised to a greater degree at higher education. The technical disciplines which UK employers find scarce are thus better provided for by some European and other countries' curriculum structures.

34. It is also observed that the secondary IT and science curricula have been seen by many as dull, and have the effect of switching young people off the STEM area. The new GSCEs are intended to maintain good levels of subject depth and breadth in a way that is more engaging for pupils and offers greater flexibility for teachers. They have the potential to provide an emphasis which connects these subjects with what a career can in fact look like, and which shows that what is learned can be used in non-science areas. Many of these areas have direct appeal to the "text-messaging generation", who can benefit from clear articulation of the link between the knowledge gained in STEM subjects and the careers for example in YouTube or Google. These are not necessarily technical jobs per-se, but are sectors in which some technical knowledge is a real benefit. It can also emphasise that STEM subjects at school do not narrow career options to the white-coat occupations, but on the contrary broaden the range of real career options. All employers, whether in STEM areas or financial or business services, have an interest in getting this message into primary and secondary schools.

35. There is also a concern that the IT A-level focuses too much on the 'easy' IT-user skills, such as operation of the popular Microsoft applications. Whilst these may be skills which can be put to early use in an employment context, it is vital that they do not displace the attention given to the core IT knowledge and understanding that forms the basis of an informed awareness of how IT is developed and structured and how it interfaces with other disciplines.

Career decisions – aspiration and options

36. Linked to curriculum development are the issues around the support of young people when making their A-level choices and starting to consider their career options. Whilst this stage of decision-making tends to be centred around the school curriculum, there are key inputs required from careers advisors, parents, employers, government agencies such as Connexions and others. In addition it is important that support for future decisions is provided from age 11 and not simply in the run up to 16 when many people make choices of subject for A-level, Advanced VCE, International Baccalaureate or other equivalent qualifications. It will be important to observe the effectiveness of the Government's *Next Steps* commitment to a pilot of 250 after school science clubs from 2006. These are intended to offer an engaging and stretching programme of activities for the 11-14 year age group to pupils with interest and potential in science.

- Career advisors: there is a commonly held view that the capacity for many school careers advisors to do justice to the range of careers open to someone at secondary age is quite limited. An accurate grasp of what many STEM-related careers consists of in practice is not easily assimilated by someone who has not had direct exposure to the sector, and it is arguable that employers themselves have often described only the specialised scientific work areas, and not the more general ones which nonetheless benefit from a good understanding of scientific issues and principles. The Government's *Next Steps* document indicated a commitment to working with stakeholders to improve the careers advice given to young people and their parents.

- Parents: whilst the student is seen as the primary audience for careers advice, the influence of parents is very strong, and an initial interest and enthusiasm for STEM on the part of a student can easily be snuffed out if the parents' view is that studying science can only close down options to a career in a laboratory. Parents have a large influence at this point – and are themselves in turn quite difficult to influence. They need better to understand the options, to be interested in the issue, and to be able to give more informed advice and encouragement.

- Employers: the picture here is diverse. Some employers do a great deal to support the work of schools both in the teaching of science and in helping explain the reality of many STEM career options. Others are not engaged, see no need or payback, or are simply unaware of how to contribute. Indeed the large employers who are active in this area can find themselves asked to support an ever increasing plethora of schemes, tending to create a level of confusion, and with few measures of success. The work of schemes like SETNET and of some of the RDAs does much to alleviate this.

- Connexions: for this service the range of careers to be covered is so wide that its task is extremely challenging and whilst providing a good focus for support for students who are having difficulty with progression, it has inadequate resources to advise an average or bright child. Poor careers advice is a major issue and is bound to affect the ability of students to make informed decisions.

37. Some initiatives to support schools in the STEM area and to generate enthusiasm in the student appear to have been very successful and well supported. SETNET has been funded for a number of years through the OSI. Additional funding has recently been provided in 2006 for the establishment of regional coordination, and the Science and Engineering Ambassadors programme now has 12,000 participants going into schools, of whom 50% are under the age of 35, 38% are women and of those who declare their ethnic origin around 15% are non-white. Originally SETNET primarily coordinated the SETPOINTS, but its focus is being widened. With this broader STEM remit, its priorities are now to track impact, provide a local and regional brokerage facility for schools, leverage other funding sources and to establish further its role as “first port of call” for schools wishing to access STEM enhancement and enrichment support.

38. As regards IT careers, the focus here has been on the need to change the attitude of a generation. Computer Clubs for Girls (CC4G) scheme operated by e-Skills UK took as its primary focus to change girls’ attitudes at 10-14 years towards IT.[17] They did this by relating computers to topics that are of interest to that group – for example fashion or celebrities. Having piloted CC4G in 2005 with SEEDA in 28 schools, the scheme has grown so that 2054 schools are now involved, with the chance to capture the imagination of well over 50,000 girls at the age when they typically become disinterested in IT. Club sessions are generally facilitated by employer representatives who receive training from e-skills UK; gaining the buy-in of the often very enthusiastic employers is likely to be key to the scheme’s future success.

39. Use of the internet and of web-portals to support the whole question of career related decision-support is a growing area. In particular the Engineering & Technology Board’s SCENTA careers site provides access to a large base of information, both editorial in nature and links to a wide range of other organisations in the STEM field. The site makes a priority of addressing the issues in the language of the young student: *“Welcome to scenta careers…In this microsite you can find stacks of information on careers in STEM. Whether you're at school, uni or already in work we've got helpful info just for you”.* The Science Council is also developing a website, *Careers from Science*, which is expected to form a valuable resource and will be rolling out and expanding in phases from Spring 2007. These sites are designed with the needs of both the student and the careers advisor in mind. Another initiative involves four Sector Skills Councils together with LearnDirect which are working with careers advisors to build their ability to give advice about specialist industries including the STEM sector through a series of workshops for groups of up to 40 careers advisors

40. RCUK has an element within its Science and Society Strategy programmes aimed at schools and young people through which it funds a series of external activities addressing STEM careers and attitudes to them. Much of this gains leveraged effectiveness through joint funding, such as CREST with the British Association and the Nuffield schools bursaries

[17] See http://www.cc4g.net/

STEM at higher education – input and output quality

41. The quality of graduates in STEM subjects is quoted as an issue by many employers, with recruiters of the more specialised roles now searching for candidates at masters level where previously a first degree would suffice. It may not, however, always be self-evident to universities that there is a major problem. For example the HESA first destination figures[18] for 2004 science, mathematics and IT graduates suggest a satisfactory level of success in securing employment or further study, at between 72% and 81% compared with an All Subjects figure of 77%.

42. Employers also seem ready to offer competitive salaries to STEM subject graduates although HESA and AGR data provide slightly differing pictures. HESA's survey of graduates about their salaries six months after graduating shows that engineering disciplines feature as six out of the 12 highest earning degree subjects[19]. The Association of Graduate Recruiters (AGR) survey[20] questions its members only, and shows that salaries for engineering roles are around or slightly above the median for all roles. These surveys have some limitations – HESA data are subject to the factors that influence response rates, and AGR survey figures tend to capture the larger employers, with a limited SME voice – but they provide a broadly positive picture for STEM graduates.

43. The general report from recruiters is that whilst the graduate talent can be found, the extent of the required search is increasing. One cause is the different standards of knowledge of entrants to STEM subject degree courses. A response by some HEIs, for example in mathematics, has been to introduce streaming. This allows students to give attention to the topic in a way that links most strongly with their main subject. A pure mathematician will require more attention on theoretical aspects, whilst a biologist may benefit more from a strong grounding in statistics and a civil engineer in calculus. Addressing a subject in relation to how it is utilised in this way helps to avoid moving to a position where the subject is primarily studied for its own sake, and allows the value of the pure subject to be used as a model for concepts in other areas. There remains some concern that the adaptation of courses by universities may not yet be extensive enough, and is hindered by some defending of the status quo by the learned societies. The question needs continually to be asked about how to develop the traditional disciplines in the light of changing trends – for example biochemistry is increasingly delivered in the life sciences department, and this may lead to question whether the number of traditional pure chemists in the future might decline still further.

44. A related aspect of higher education curriculum development is the piloting of the accelerated or 2-year degree. The view from the sector is that this is unlikely to be a tenable model in the STEM subject areas. There are two pressures which lead to this view. First there is the demand on HEIs to provide an uplift to the subject knowledge of students upon entry to university where this is required. Second, these are subject areas where the knowledge base is continually expanding and if first degrees are to cover the developing nature of the topic fully, it is unlikely that a two-year model can accommodate it.

45. Current discussion with some of the larger STEM employers reveals a view that there may be too much freedom for HEIs to modify the syllabus, often in an attempt to create what they judge will be most appealing to students. Whilst this may benefit enrolments, employers can find that they are seeking to recruit a student without having a clear picture of what he or she has been taught. Indeed for some engineering employers, the tendency is to take other science and mathematics graduate recruits towards Chartered Engineer status alongside engineering degree peers. They note that after three or four years the distinctions between the subject specialisms are lost, and conclude that universities could reduce their frequent adjustments to courses and content. The employers' focus is on graduates with a grasp of the fundamentals upon which their career development programmes can build, and what they sometimes see as "flavours" in course design are of limited value.

[18] Summarised in HECSU *What do graduates do? 2006*
http://www.prospects.ac.uk/cms/ShowPage/Home_page/What_do_graduates_do__2006/p!efbcdLp

[19] Summarised in ETB: *Engineering UK 2005* http://www.etechb.co.uk/pdf/Engineering_UK_2005.pdf

[20] AGR Graduate Recruitment Survey 2006 - Summer Review

STEM careers and earnings

46. Roberts recognised an issue with the attractiveness with which STEM careers such as those in research and development were perceived, and made recommendation to address this. As indicated above, the starting salaries for STEM graduates moving into employment are generally competitive. Furthermore a study in 2005 by Pricewaterhouse Coopers for the RSC and Institute of Physics[21] showed a life-time earnings premium for graduates over A-level holders of approximately £129,000 in current terms, rising to £185,000 for graduates in chemistry and physics. Earlier analyses summarised by CIHE also showed the additional wage premium from studying STEM subjects.

47. R&D in sectors such as pharmaceuticals and electronics do attract good numbers of applicants, but the manufacturing and materials areas have much more difficulty. Indeed the capability for many manufacturing activities to be off-shored, where the STEM skills supply is less constrained, is leading to a view that the supply for much of this talent is increasingly a global one and need not be limited to the UK, especially for worldwide brand employers. This is reflected in engineering as one of few global professions with a worldwide skills market in which the work can be moved to where the skills are located. It contrasts with medicine for example, where the skills are global but the practitioner needs to be on-site. This may help to explain why, despite a UK shortage of STEM skills, salaries have not risen. Equally, whilst some recruiters have differential starting salary structures for STEM graduates, the majority do not.

48. Salaries offered by the financial services sector, where many STEM graduates can and do thrive, have out-competed the commercial and academic sectors substantially for some time. Some STEM graduates will continue to be drawn there. However, it is not just the salary that deters them – as one employer puts it "either they want to do engineering, or they don't and can't be persuaded". Professional career paths and growth structures can be designed for those that do choose a technical career, so that they can advance without needing to move into large managerial roles. Equally STEM specialists have succeeded to chief executive and other positions of seniority. The diversity of opportunity might be better explained to students of all ages.

Higher education and business involvement – the skills dialogue

49. The question of curriculum development in the STEM subjects in higher education has a substantial bearing on employer involvement. Roberts made several recommendations here, focusing on promoting close interworking and cross-fertilisation between the sectors. CIHE's report on international competitiveness[22] explores many examples in detail. Larger employers commonly have a series of links with academic departments, offering the opportunity to contribute to course design. Some report that HEIs are slow to take up the offer, and note the contrast with American universities which use such collaboration as a feature of their marketing to prospective students. The 2005 launch of the IT Management in Business degree by e-skills UK is an example of the use of close employer involvement in syllabus design and in the setting of entry standards – in this case significantly higher than for the existing computing and information systems courses. It addresses employers' concerns that graduates commonly take two years in employment to become fully effective and focuses on combining the development of enough knowledge of software to be able to manage it (rather than write it), with strong project management, interpersonal and other business skills.

50. There are many examples of work that address the Roberts recommendations about increased engagement between academics and business people. Some of these were already in operation, others have emerged or the extent or process has been revised. The pharmaceuticals sector is very active, deriving largely from the focus it places with university research teams on new product development and commercialisation. Retail and some of the utilities increasingly sponsor research capabilities in areas of concern – for example environmental science. Knowledge transfer partnerships are common, often put in place with universities by

[21] The Royal Society of Chemistry and the Institute of Physics (by PricewaterhouseCoopers LLP):*The Economic benefits of higher education qualifications (*Jan 2005)

[22] CIHE, Richard Brown and Philip Ternouth: I*nternational Competitiveness: Businesses Working with UK Universities* (May 2006) http://www.cihe-uk.com/docs/PUBS/0605ICSummary.pdf

many in the engineering sector. Some relationships of this nature have good value to the university in particular by offering a continuity of rolling funding that goes beyond the typically fixed-term project funding streams that can hamper planning of the research talent pipeline.

51. The Government response to Roberts in *Science & Innovation Investment Framework 2004-2014* led to the setting up of the UK Science Forum. This body has been active and through its Skills Working Party has influenced some key aspects of the recent *STEM Programme Report*, such as the inclusion of a substantial business voice on the high level STEM Strategy Group. It is significant that business has not simply been involved in an advisory capacity, but in a role that impacts directly on strategy. It may be that science, technology and engineering thus establishes a voice similar to that of the Government Chief Advisor for Mathematics which followed the Smith Report, and who meets regularly with Ministers to address the specific learning agenda. The UK Skills Forum is expected to move ahead on three prime areas of focus; the image of science, STEM skills and innovation. All of these can be expected to have an impact on Roberts recommendation areas.

52. However, the specific recommendations regarding placements between academics and business people have been less fruitful. Some university careers services have taken a lead role, engaging with employers on behalf of the university and with academics in the departments. Others see little benefit and doubt that it would have a significant impact; most see resources as insufficient to support extensive activity in this area. More significant however is the outlook of the potential participants. Academics essentially further their career by publishing, and the prospect of an industrial secondment threatens to create a gap in their publishing record. Thus a secondment opportunity, although offering to broaden an individual's outlook on their subject and to provide unique learning insights, may have limited appeal to a research academic or to the head of department driven by RAE ratings. By a similar token, most business employees are not drawn to a secondment in academia because they would have taken that path initially if they had a central interest in research work – especially in view of the fact that much industrial research is being commissioned out to universities.

53. The Regional Development Agencies play a role in the area of skills dialogue, generally as part of their innovation work. The RDAs recognise that STEM skills are central drivers of innovation, but that leadership skills are also vital and demand development alongside advanced technical skills. Regional Skills Partnerships establish a network for the matching of skill needs and supply, but involvement of some parties has been slow to establish. Some regional STEM support centres begin to provide a critical mass in this area. RDAs do not operate as core funders but as initiators to get things off the ground. The roll out of Computer Clubs for Girls, for example, was assisted by the collaboration between SEEDA and e-skills UK.

54. A range of initiatives at present are showing evidence of a more engaged landscape between employers and higher education regarding these skills. For example the brokerage model of the Train to Gain programme, funded by DfES and delivered by the Learning & Skills Council, is being applied to facilitate an active connection between the higher levels skills development which HEIs can provide and the employers who have not tended to articulate their training needs in this way in the past. HEFCE's recent strategy for employer engagement[23] demonstrates the three regional higher level skills pathfinders which are intended to lead to an enhanced dialogue and provision in this area. The development and uptake of Foundation degrees over recent years, to a 2004/05 HEI intake of 10,370 full-time and 6,360 part-time students, is further evidence of this engagement. Lifelong Learning Networks, where activity includes HEIs and the Learning & Skills Council, can illustrate and promote the more flexible approach to cross-over between academic and vocational routes within a professional career pathway, supported by the curriculum developments that can make this an increasingly attractive option to individuals and to employers.

Trends in the funding of teaching at higher education

55. The Roberts recommendations on undergraduate course structure led to debate on the recurrent funding for the teaching of STEM subjects. The specific recommendation that the teaching premia for science and engineering subjects should be reviewed and amended is one where the employer view is generally that the Government or funding bodies "still need to bite the bullet". In November 2006 HEFCE announced additional funding of £75M over three years to support the teaching of chemistry, physics, chemical engineering and

[23] HEFCE: *Strategy for Employer Engagement* (2006) http://www.hefce.ac.uk/learning/employer/

mineral, metallurgy and materials engineering[24]. This increases the teaching grant for these subjects – seen as strategically important, but vulnerable – by about 20%. Further support for the demand side entailed HEFCE contributing £11.5 million to a total £18 million funding for a number of two to three-year projects[25] being run by The Royal Academy of Engineering, the Institute of Physics, the Royal Society of Chemistry and a consortium of mathematical societies. Each is leading projects in their topic areas, and aims to increase awareness of what studying in these fields can offer and to widen participation of young people in them. The support also involves the various organisations working in collaboration.

56. However whilst this additional funding is welcome, a longer-term solution is needed and this is likely to involve the TRAC methodology[26] enabling the price paid for high cost subjects being brought closer into line with the costs incurred in delivering them. The challenge remains for the longer term to refine the balance within the fixed funding budget, whilst retaining flexibility at the institutional level, so that internal cross-subsidy does not simply deprive another area of funding. There may need to be further recognition of the cost of supporting those subjects which are seen by the Government as genuinely strategic in importance.

57. A related issue concerns investment in teaching laboratories. Here funding is generally seen to have been provided by HEFCE and to have been spent on laboratory improvement. A question remains whether this has impacted sufficiently upon teaching laboratories, or mainly upon research facilities. CIHE members think that CSR 07/08 needs to earmark funding for capital to ensure that an unequivocal start is made on the upgrading of teaching laboratories.

University careers advisory services

58. Alongside the building of relationships through secondments between business people and academics, Roberts recommendations for university careers services included a focus both on enhancing the information that STEM students have about the full range of career options open to them, and particularly on building links with small businesses so that opportunities in the SME sector were fully uncovered. Activity here has been quite mixed, but the careers services association, AGCAS has for example established active links with the STEM Sector Skills Councils (although not all SSCs have responded to the opportunity), and with organisations such as the Engineering Council, Engineering and Technology Board, Institute of Physics and Royal Society of Chemistry, as well as the HE Academy Subject Centres. It has produced a DVD to promote careers in SMEs to graduates, though not exclusively in the STEM areas. AGCAS has also worked with RDA funding where available to develop the means to forge stronger links through support for student placement, recruitment support or local graduate jobs website. Many individual careers services have built a series of wide ranging links. One for example has established a cross-university Employability Forum, chaired by a Pro-Vice-chancellor with a wide participation including academics and employers

59. Steps such as these have in some cases been driven by the recommendations of the Harris report[27] which Roberts strongly endorsed. Larger employers see their relationship with university careers services as key to their recruitment success, and many STEM graduates go into employment which is not STEM related, for example financial services where their numeracy and analytical abilities are valued. A study into innovation by the DTI[28] shows the extent of this (Chart 1). It found that enterprises with a high overall level of innovative activity have roughly twice the average share of employees educated at degree level. Even more significant, whereas the innovative engineering based manufacturing businesses have some 8% of their employees as graduates with science and engineering degrees and 4% with other degrees, the knowledge intensive service businesses (including financial services) have 24% of their employees with science and engineering degrees and 20% with other degrees.

[24] HEFCE: *Provision of an additional £75 million to support very high cost and vulnerable science subjects* http://www.hefce.ac.uk/news/hefce/2006/science.htm

[25] HEFCE: *Working in partnership with Government to build student demand for STEM subjects* (Oct 2006) http://www.hefce.ac.uk/news/hefce/2006/stem/

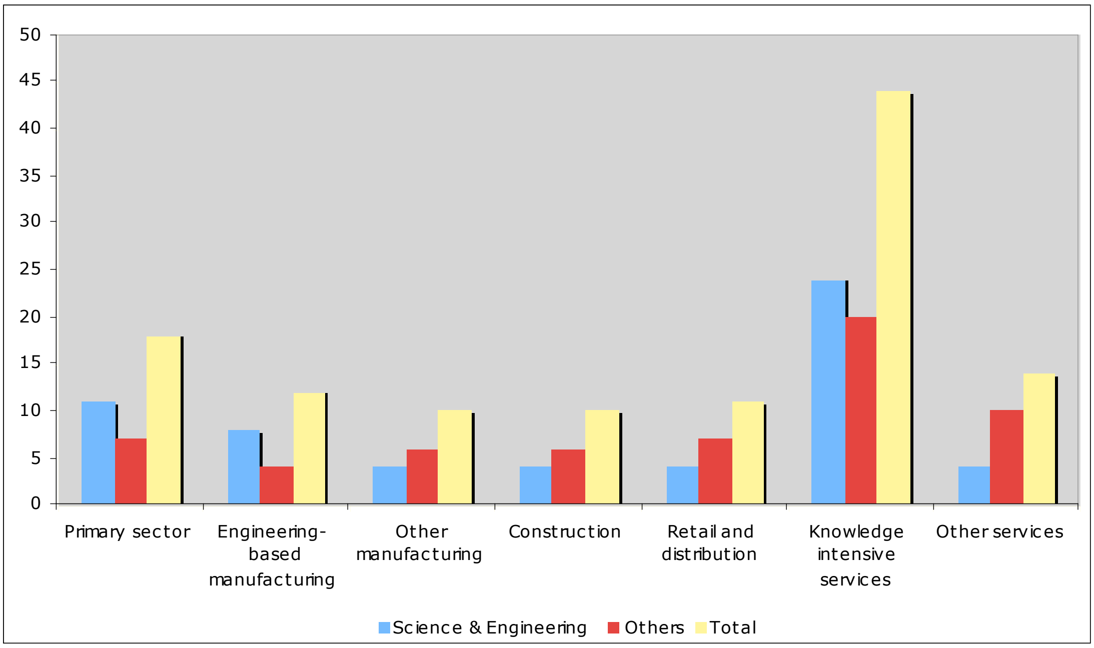
[26] HEFCE, Joint Costing and Pricing Steering Group: *Transparent Approach to Costing – an Overview of TRAC* (2005) http://www.jcpsg.ac.uk/guidance/about.htm

[27] DFEE: *Developing Modern Higher Education Careers Services - Report of the Review led by Sir Martin Harris* (Jan 2001) http://www.dfes.gov.uk/hecareersservicereview/report.shtml

[28] DTI Occasional Paper 6: *Innovation in the UK: Indicators and Insights* - table 1.4 (Jul 2006)

60. A service-led economy needs graduates and postgraduates who have the analytical approaches and discipline that STEM engender. The fact that only one third of those who have studied chemistry use that discipline later in life[29] should not matter; chemistry and other subjects termed strategically important help to underpin our service sectors as well as our manufacturing companies. It should be no "surprise" (to use the DTI's phrase[30]) that there are so many STEM graduates in the knowledge-intensive service sectors.

Chart 1: Average number of employees (%) educated to degree level in science and engineering



Source: DTI Occasional Paper No. 6, Innovation in the UK: Indicators and Insights, July 2006.

The study of STEM subjects should be encouraged not only because of their significance for our high value manufacturing businesses but also because so many STEM graduates and postgraduates work in the City of London and underpin the success of our knowledge intensive financial and business services sectors.

61. Careers services can vary quite widely in terms of their responsiveness and their commerciality. They generally put great effort into engaging with employers and with academic departments but there are interesting parallels with other countries. Italian universities have little in the way of careers service, and as a result individual academics forge closer links with employers – engineering professors in Italy see their role as helping their students to become employed as engineers; Spain and Germany are similar. In the UK the role is seen primarily to teach engineering and the career service deals with employment advice. The scale of student numbers is putting the careers services under increasing pressure, and has driven a move to the adoption of technology-based solutions to contribute to the task of advising students. Large employers are generally able to fund the development of recruitment approaches that can use this infrastructure; it is the SMEs which may be able to gain most benefit from the support of the careers advisory service.

Trends for postgraduates – PhD study and postdoctoral careers

62. Several Roberts recommendations addressed the issues around postgraduate education and careers from two main perspectives – the short-term attractiveness of studying for a PhD and the preparation it provides for a longer-term career. This is an area where the recommendations have generally been well implemented, although the issue of declining STEM postgraduate numbers has not been resolved. Additional funding was provided by the Government in the Science Budget 2003/04 to 2005/06 to enable Research Council PhD stipends in areas of recruitment difficulties to rise significantly beyond the minimum levels of £10,500 in 2004/05 and £12,000 in 2005/06. This still faces PhDs with an income gap in relation to the average for first degree graduates going into employment, but the margin has been significantly

[29] See eg CIHE, Mason: *Change and Diversity: the challenge facing chemistry higher education* (1998)

[30] DTI ibid page 16

narrowed, and the annual report on the 10-year Framework[31] confirms that “the increase in the stipend to that of a living wage in particular has made a big difference”. It should be noted, however, that adjustment of the stipend is not regarded as having addressed the supply issue from UK-domiciled students, as 50% of STEM PhD studentships are taken up by overseas students[32]. With the increase in opportunities in the Asian countries from where so many overseas postgraduates come, the UK cannot continue to rely on such researchers choosing to remain here and underpinning our research capabilities.

63. RCUK together with the UK GRAD Programme (UK GRAD) have been highly proactive in adopting the recommendations in Roberts, both in attracting people to PhDs and in then helping to build their skills. 50% of PhDs progress out of academia and there has been recognition that CPD must cover the transferable skills that are needed to support this aspiration, whilst at the same time providing the career development tools that are required for an academic research career. The UK GRAD scheme has applied funding of £2.2 million per annum to drive the establishment of skills development schemes, a key point of which is that they are embedded into the academic process of research degrees. This funding, together with about £12 million from RCUK which has become known as “Roberts Money”, has provided for the development of a population of skills trainers within HEIs – deliverers of training, careers advisors and other skills provision. The Roberts recommendation that PhDs should have scheduled time dedicated to skills training each year has come to be interpreted by most HEIs as a valued enhancement rather than a compliance obligation. It has been supported by the £12 million of ring-fenced cash, which HEIs have to account for, and is an example of a recommendation being backed up both with funding and a process to ensure it is spent as intended. Much sharing of good practice in this area between HEIs, facilitated significantly by UK GRAD, has contributed to the success of this initiative. Thus research programmes are being very widely impacted, although the effect is not yet being felt by all research students; perhaps inevitably some departments insist on a more voluntary approach than others; some academics resist taking the ownership required. However it is probably not going too far to say that the work following this Roberts recommendation is transforming the researcher’s development and has brought about the start of a culture change across academia.

64. In addition to the well-developed processes for sharing best practice in this area, there is also a good synergy with the QAA code of practice and the Research Councils’ joint skills statement, which will be covered by the February 2007 audit of the implementation of QAA codes. Employers’ perception is that some PhD graduates can still find it difficult to transfer from the academic research environment to the external workplace. Two specific solutions to this are now more within the PhD’s reach: engagement, as hitherto, to work on a co-sponsored basis at the HEI, or transfer to the workplace with the benefit of the CPD that has been received.

65. To address issues noted by Roberts in the postdoctoral research career, the recommendation to fund 1000 additional academic fellowships has been implemented and is now seen in a series of five-year fellowship awards. The host University guarantees the fellow a permanent academic position following the end of the award, subject to the successful completion of a probationary period. Typically an Academic Fellow will be supported by research funding from another source during the first two years of the award, and as the fellowship progresses, will undertake an increasing amount of lecturing, project management and outreach to schools. RCUK administer this scheme and note that application levels are high. Professional and skills development has been introduced and promoted within the postdoctoral area, as in the postgraduate field, in response to the Roberts recommendations and consequent funding.

66. The more significant issue at the postdoctoral level is the career structure itself. The short-term nature of many research contracts has been addressed in an employment context by recent legislation to convert repeated fixed-term contracts into open employment contracts. However the issue of short-term project funding and the income flow to sustain research staff remains. The progression path in an academic research career is still quite flat and whilst a transfer into a teaching role can accelerate it, it remains a relatively rare step for researchers to take. The individual postdoctoral researcher holds specialist knowledge and skills which is often vital to the work of a department, and their ‘loss’ into a teaching role can thus have serious consequences for a department’s research capability.

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[31] HM Treasury: *Science and innovation investment framework 2004-2014: Annual Report 2006* http://www.dti.gov.uk/files/file31810.pdf

[32] Universities UK and SCOP: *Patterns of Higher Education Institutions in the UK: 6th Report* (Oct 2006) http://bookshop.universitiesuk.ac.uk/downloads/patterns6.pdf

Employers and innovation

67. The skills that employers need are changing. Off-shoring for example leads companies to place a greater premium on graduates with skills such as project management and systems integration. A future built on knowledge-intensive organisations requires more graduates and postgraduates to have a capability to innovate, be enterprising, and to have networking and communication skills. Such an approach has to start in schools.

68. The Roberts Report set a focused agenda and the Research Councils, for example, have shown what can be achieved when specific recommendations are seized upon and driven. The DfES STEM Programme Report recognises the need for coordinated initiatives in the learning and teaching arena and provides a framework for this. Similar coordination is now needed across all the many employer initiatives in this area. With appropriate joined-up working, a significant and lasting impact can be made on the vital decisions that young people make at GCSE, A-level and equivalent, graduate level and beyond.

ANNEX A

Acknowledgements

We are most grateful to the individuals and organisations who were invited to provide their views and who contributed comments, whether by meeting the researcher, participating in a telephone interview or making written comments.

We are also grateful to LogicaCMG for funding the work and for the support of the CBI and the ETB in particular.

Margaret Dane	AGCAS
Chris Jackson	AGCAS
Carl Gilleard	AGR
Dr Derek Bell	ASE
Beckie Akers	Centrica plc
Phil Bunyan	CLEAPSS
Louise Porter	Corus plc
Dr Linda Bradley	DELNI
Amber Longstaff	DfES
Sophie Ingram	DfES
Karen Price	e-skills UK
Dr Barry Cleasby	ETB
Matthew Jaffa	Federation of Small Business
Helen Hambleton	GlaxoSmithKline plc
Rama Thirunamachandran	HEFCE
Paul Hazell	HEFCE
John Selby	HEFCE
Charlie Ball	Higher Education Careers Services Unit
Roger Carter	Higher Education Funding Council for Wales
Lynn Gardner	House of Commons Science and Technology Committee
Dr Gavan Conlon	London Economics
Sarah Graham	National Grid
Professor John Holman	National STEM Directorate / National Science Learning Centre
Thomas Westgate	Parliamentary Office of Science & Technology
Mick Waters	QCA
Markos Tiris	Quality Improvement Agency for Lifelong Learning
Dominic McDonald	Research Councils UK
Iain Cameron	Research Councils UK
Ken Fulton	Rolls-Royce plc
David Lott	Scottish Funding Council
Ed Metcalfe	SEEDA
Yvonne Baker	SETNET
Graham Philpott	Siemens plc
Ben Brierly	The Institution of Engineering and Technology
Sir Gareth Roberts	The Roberts Review
Nicola Hannam	The Science Council
Professor Adrian Smith	The Smith Inquiry
Aileen Allsop	UK Science Forum
Jackie Wilbraham	UK Science Forum
Janet Metcalfe	UKGRAD/CRAC
Sherree Schaefer	United Utilities plc
Professor Drummond Bone	Universities UK
Diane Hay	University of Bath
Catherine Klimes	University of Northampton
Jo Leech	VT Group plc

ANNEX B

A draft of this report was considered at a dinner discussion kindly hosted at the Institute of Physics and at lunch discussions of some CIHE members kindly hosted by Anglo-American and the University of Westminster. We are most grateful for the additional insights offered and general endorsement of the analysis we have presented and conclusions drawn.

STEM Discussion, Institute of Physics

David Bell, Permanent Secretary DfES

Professor Drummond Bone, President, Universities UK

Lord Broers, The House of Lords

Dr John Holman, STEM Director DfES

Professor Judith Howard, Chair, The Royal Society, Higher Education Working group

Celia Hoyles, Government's Chief Advisor for Mathematics

Sir David King, Government Chief Scientist, DTI

Dr Robert Kirby-Harris, Chief Executive, Institute of Physics

Dr Martin Read, CEO LogicaCMG

Peter Saraga, President, Institute of Physics & HEFCE Board member

Richard Brown, CEO CIHE

Hugh Smith, CIHE & author of the report

CIHE Lunch Discussions

Dr Geoffrey Copland, Vice-Chancellor University of Westminster

Carolyn Eadie, Partner Spencer Stuart

Sir Anthony Greener, Chairman QCA

Professor Alan Gilbert, President & Vice-Chancellor University of Manchester

Richard Greenhalgh, Chairman CIHE

John Griffiths Jones, UK Chairman & Senior Partner, KPMG

Russell King, Executive VP Group HR 7 Business Development, Anglo American plc

Sir Michael Latham, Chairman CITB-Construction Skills

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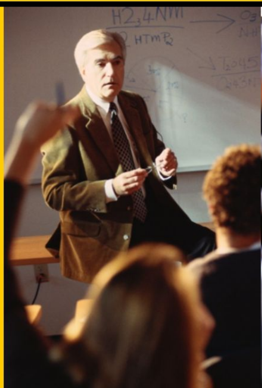

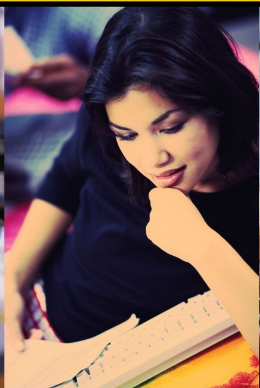


ISBN: 1 874223 62 9

April 2007, £6.00

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