REPORT TO THE SECRETARY OF STATE, DIUS ON UNIVERSITIES' LINKS WITH SCHOOLS IN STEM SUBJECTS

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SEPTEMBER 2008

Contents

SUMMARY AND RECOMMENDATIONS

Universities are already heavily engaged with schools on STEM subjects in a variety of ways. There are many examples of good practice throughout HEIs in England and we have also highlighted two examples of schools that are spearheading their own interactions with several universities. We are concerned that not all pupils have access to three science GCSE syllabus and it also appears that there is a difference in availability of provision of the three traditional science 'A' level courses depending on structure of education post 16.

Our recommendations for universities are focused on working more effectively within each institution, coordinating effectively with partners and on reviewing the balance of activity between aspiration and attainment at different stages of a pupils' development. We also see the need for more joined up provision of information, advice and guidance on careers and pathways of attainment in STEM subjects starting in secondary school and continuing through undergraduate study at university. Our report should be seen in the context of the considerable activity by many groups to address concern around STEM subjects and wider issues such as widening participation and fair access including the work of the National Council for Educational Excellence.

Our formal recommendations are as follows:

Recommendation 1: We recommend that universities formally recognise as institutions that such support – whether of aspiration or attainment – is part of their role in STEM subjects

Recommendation 2: We recommend universities share their approaches more so that the dissemination of best practice can be more readily achieved.

Recommendation 3: We recommend universities seek to co-ordinate better internally to ensure that they maximise impact.

Recommendation 4: We recommend that Universities should also ensure that they maximise leverage from other activities by joining up their existing initiatives – such as those more generally aimed at widening participation

Recommendation 5: We recommend that universities review their activities to get a balance between activities related to aspiration and attainment at different stages of a pupil's development

Recommendation 6: We recommend that universities make sure they work with other partners.

Recommendation 7: We recommend that government gives thought to providing a mechanism to enable such an Information, Advice and Guidance pathway for all pupils.

OBJECTIVE

In June 2008, the Secretary of State wrote asking us to look specifically at university links with schools in STEM subjects (Annex 1). STEM subjects are defined as those in Science, Technology, Engineering and Mathematics. We recognise that Professor Steve Smith is leading a work stream on higher education for the National Committee for Educational Excellence (NCEE) which is looking at university links with schools in general. We also know that there is a study of employer demand for STEM being undertaken by DIUS and BERR. Our report is designed to focus upon the role universities could and should play, both directly and indirectly, in STEM subjects.

Specifically, we were asked to make recommendations on two key issues:

> ***What more can universities offer to enhance their impact on STEM for young people?***
>
> ***How can universities improve their existing involvement with schools?***

We made an interim response in July 2008 (Annex 2). This report is our more detailed response to this request.

BACKGROUND

Previous reports

There is ample evidence from previous reports that there is concern in the sector that more must be done to ensure that more young people are excited by the prospects offered by STEM subjects and the avenues that this opens up for them in choosing university courses and later careers. In this section, we put our work into context of others concerned with increasing participation in STEM subjects at school, university and as a career.

In 2002, Sir Gareth Roberts published 'SET for success' [1] which focussed on the supply of people with science, technology, engineering and mathematics skills. Many initiatives stemmed from this report mainly aimed at improving skills and retention at university. There has been continual review of the STEM sector since 2002 including, for example, 'Science and Innovation Investment Framework 2004-2014' [2] in 2004 and the follow up 'Next Steps' [3] in 2006 , the DFES-DTI STEM programme report [4] in 2006 and the 'HEFCE working in partnership with government to build student demand for STEM subjects' [5] .

In 2006, the Royal Society produced a report 'A Degree of Concern' [6] that focused in detail on statistics for science subjects showing that the increase in numbers was not necessarily in the traditional areas in which skills are required. Employers' organisation have also invested time in reviewing STEM skills e.g. review of STEM skills supply chain from CIHE [7] in 2007 and an Engineering and Technology Board report on labour supply and demand in science [8] in 2006.

The Campaign for Science and Engineering in the UK, CaSE , has continued through one strand of its activities to look at the state of science education in the UK through various reviews such as that on careers guidance (2007), secondary school science education (2007) and delivering diversity 'making science and engineering access to all' (2008).[9]

Mathematical skills are usually required in the sciences and there has also been concern on the level of numeracy skills. 'Making Mathematics Count' [10] was an influential report from Professor Adrian Smith's inquiry into post 14 mathematics education. More recently, Reform, an independent think tank, has published a report on the value of mathematics [11] in which they claim a generation of lost mathematicians has been at considerable cost to the economy.

Demand for STEM skills from Industry

The demand from industry for appropriately trained workforce in STEM subjects continues with, for example, the report from the CBI/EDXCEL education and skills survey 2008 [12] and the Work Foundation on The Knowledge Economy[13]. There is now a call for evidence from DIUS about demand for STEM skills. This closed on 1st September 2008.[14]

Widening Participation

It is also clear that the widening participation agenda remains crucial to policy and is being actively pursued across the sector. Whilst there is evidence that teaching students from less traditional or less well prepared educational backgrounds is both more expensive and more challenging, when they are in university there is nonetheless a great concern to ensure that previously under represented groups are engaged and recruitment from such groups is sought. No university can afford to waste talent and it is evident that talent can be found widely distributed across the population. The Sutton Trust report – 'Wasted Talent? Attrition rates of high-achieving pupils between school and university'[15] makes clear the extent of the problems that remain.

We are aware that the NCEE HE work stream, chaired by Professor Smith, is discussing recommendations in this area and the report from the NCEE meeting on 22 April 2008 [16] indicates that members agreed proposals among other things for:

(i) Business engagement in primary schools; raising awareness of the world of work and developing enterprise skills as well as supporting science, technology engineering and maths and

(ii) For the HE strand, the importance of information, advice and guidance was emphasised, as was the value of HE engagement with schools and colleges to raise both attainment and aspiration.

The final recommendations from the HE work stream of NCEE are around good information, advice and guidance for pupils starting at primary school. We are pleased to see the recommendation that 'government should ensure that primary, secondary schools and colleges are enabled to provide better STEM (particularly maths) skills to pupils to ensure that take-up of STEM courses at a higher level is not constrained by lack of capacity or inappropriate IAG. Schools should continue to develop dedicated activities to promote participation in STEM subjects and modern foreign languages and HEI links with schools and colleges should support this'.

Science Technology Engineering and Mathematics Programme

The Centre Director for the National Science Learning Centre, Professor John Holman, has been appointed National STEM director with the aim of leading the STEM programme to rationalise and improve the provision of support for students[17]. His remit is to put into practice the recommendation of the STEM programme report and there is an advisory board, the STEM High Level Strategy Group with wide membership. In 2007, the National STEM Director's recommendations around high quality careers information, STEM awareness, the appointment of a STEM career coordinator and a National STEM awareness campaign were accepted by government.

There are now ten science learning centres offering continuing professional development for all those involved in science education [18] as well as STEM centres, [19] now known as STEM partnerships, which are a series of regional 'hubs' that provide up-to-date information, support and advice to schools about quality STEM activities that enhance and enrich the curriculum.

The STEM Network (STEMnet)[20] is funded by DIUS and DCSF with the aims of ensuring that more young people, regardless of background, in the UK make a choice to enter STEM related careers at all levels, and future generations are properly informed about the science and technology that surrounds them. It does this primarily through funding of the regional STEM partnerships, through funding of science clubs within schools and through a flagship Ambassadors Scheme. These science ambassadors are individuals from a wide variety of STEM backgrounds, from all across the UK, who offer their time, enthusiasm and expertise to help schools inspire young people. They represent over 1000 different employers, from large multi-nationals to SMEs and other organisations like the NHS, and the Environment Agency. Many ambassadors are also undergraduates and others studying or working at universities across the UK who act as role models through the work they do in schools.

Perception of STEM subjects

Finally, we note that for STEM subjects in particular there are added motivational and structural issues which might inhibit the flow of potential entrants more than in other disciplines. They have a reputation as more challenging disciplines in and of themselves within the university curriculum (perception is as powerful as reality in this regard) they build more fully upon the necessary pre-requisites of pre-entry specialisation than many other disciplines (recent reports that 'A' levels are harder might also inhibit appropriate choices) and they are very dependent upon both the availability of appropriate sciences within the school system and the quality of that provision.

We also note that the downturn of numbers of students taking 'A' levels in science subjects has been somewhat halted in that the numbers taking

maths and science ‘A’ levels in 2007 have risen in England with a 7.5% rise in mathematics compared with 2.7% rise for entries as a whole. Further maths was also up by 15.5%. Increases were also seen in biology, chemistry and physics. [21]

In summary, the study of STEM subjects in schools and at University has led to a number of concerns in recent years by a number of different constituencies. However, there is considerable effort by many parties to address these concerns. We note that high quality careers advice and promoting aspiration in students are recurring themes. The HE sector has been heavily involved in widening participation initiatives including outreach in STEM subjects. In the rest of this report, we focus specifically on the role of universities in encouraging and aspiring young people into science and in enhancing the study of these subjects.

CURRENT UNIVERSITY SUPPORT FOR SCHOOL IN STEM

In light of the previous review of activities, it is clear that it is impossible to take this report in isolation. It is part of a range of initiatives underway and relates directly to certain aspects of other work already commissioned. For example, the NCEE HE work stream, under the direction of Professor Steve Smith, has undertaken a detailed consultation of universities on their interactions in general with schools some of which has a very direct bearing on relationships regarding STEM. All universities responded to this consultation. The range and depth of work is commendable. We have had access to much of this information, courtesy of UUK and other agencies, and it has been supplemented by specific surveys requested as part of this work. We have been careful not to alienate the sector by demanding too much new information through potentially conflicting and overlapping surveys but sought to harness known information and supplement selectively that which was already extant. In order to determine whether there was any variation in activity depending upon region or orientation of university, we sought input from regional associations and mission groups as well as from Guild HE.

It is not easy to either summarise or comprehensively categorise the large amount of information that is available. However, it is clear that a large number of universities and higher education institutions take the support of STEM subjects very seriously and offer a wide variety of events within and through links outside the university intended both to aspire and to help attainment.

It is possible to identify a series of initiatives that address the chronology of preparation for and entry into STEM areas within the sector.

- It is necessary to make potential students, *at a very early stage*, aware of the opportunities in career and what it will take to enter university – this is both **awareness creating** and **aspiration raising**.

- There then needs to be a match between both appropriate **advice and guidance** and the ability to follow study appropriate subjects *post 14*. This will be fundamentally dependent upon the **availability and type of** GCSE and diploma **provision.**

- The level and quality of support students will receive may be dependent upon the **quality and orientation of the school** and it is clear that universities are actively engaged in many ways at this level not least through **support to both schools and teachers**.

- There is then the need, as students enter *post 16* education to ensure that there is **no ambiguity about what underpinning achievement will be required,** how it will be obtained and the way it will translate into specific discipline choices at University. Active university engagement through **visits** and **access to facilities** and indeed **direct teaching input** is evident in a large part of the sector.

The activities undertaken by universities seek to positively address the range of concerns covering this cycle from raising awareness to eventual entry.

Exemplars from university engagement activities

It is impossible to be exhaustive in covering the whole range of engagements from universities but the following exemplars illustrate some key points that underpin the recommendations we ultimately make.

Further mathematics networks are present across the country and seek to provide further maths inputs into local schools. There is a National shortage of specialist maths teachers per se but this shortfall is felt most acutely at the highest levels. Given the importance of mathematics to the whole STEM agenda, this is a fundamental input. In its own words, The Further Mathematics Network aims to:

- work to increase the number of students studying AS/'A' level Mathematics and Further Mathematics.
- give every student who could benefit from studying Further Mathematics the opportunity to do so.
- provide training and support to teachers of AS/'A' level Mathematics and Further Mathematics.

The involvement of Universities in the network is crucial and the type of engagement needs to be shaped to the specific regional context as well as contributing to the National agenda. Whilst the networks are keen to ensure that they are promoted by a partnership and not 'owned' by any one constituency, there is no doubt that universities need to play a pivotal role in them. A key facet of the way in which the centres work is that they explicitly address the early years as well as immediately pre-university. They are as much about awareness raising and inspiration as they are about technical reinforcement of ability. The problem solving approach and the use of engagement events, conferences and action related mathematics work also demystifies what is often seen as an abstract and 'hard' subject.

Many universities ensure that they reach out from the campus through *Ambassador schemes* either alone or as part of national networks supported by professional bodies and learned societies. In general the Ambassadors drawn from the student body forge links with schools and act as champions for STEM within those schools. Some report activities where students return as Ambassadors to the school from which they have come to act as both Ambassadors and role models for younger pupils. Ambassadors drawn from the staff often have a broader brief and work regionally or nationally and act as key links into the institution. These are particularly effective where inspirational presentations are given and where master class type activities are undertaken. They are also able to engage on a peer basis with science teachers in regions (or indeed nationally) to provide direct support and input.

Mentors for young pupils provided from the university can also help to raise aspiration. They appear to be focused upon, and work better, at the 'A' level

stage at which time most pupils have already set themselves on the STEM path through their choice of 'A' levels. These schemes can often require a large bureaucracy for modest impact and appear to rely heavily upon the openness of the school to such initiatives. It is likely to be the case that those schools with least need are those most likely to be involved.

Role models can also be powerful in raising the aspiration of young people. There is still an image problem regarding science. It may be seen as 'geeky' or difficult. It may be seen as something not attainable for various constituencies – "not something for people like me" is a common remark. Role models, particularly if they are seen to be from the same kind of community, can be powerful in breaking down these stereotypes. The careful use of Ambassadors from the student body that can also be role models in school has the potential to make a major impact. If there were also more public role models with a high national profile there will be considerable reinforcement.

These initiatives are supplemented in some universities by placements and summer project activities. These are high impact but costly in both organisation and the placement itself for relatively small numbers. However, they can put 'champions' into schools on the return of those students that have enjoyed such opportunities.

Many universities are having a very direct engagement with pre-university preparation through the *sponsorship of schools and academies*. This phenomenon has grown significantly over the past twelve months but it is by no means uniform in geographical coverage or in style of engagement. Such approaches are to be welcomed but they are likely to be a minority of schools and often addressing the very challenging end of the spectrum. Statistics from DIUS shows that specialist science is more likely to be found in independent schools or in grammar schools so there is likely to be a considerable lag before any remedial impact from academies is likely to flow through.

Gifted and talented programmes are a relatively common feature across the sector with a number of universities individually and collectively supporting and hosting them. They undoubtedly ease the path for those students already committed to science or can confirm the indecisive. They are perhaps less successful or appropriate in terms of widening the base. To make a fundamental shift the task is to attract and excite new constituencies.

School Engagement

All activities that reach out into schools require a degree of receptiveness on the part of the school. The individual centred approaches outlined above require such commitment, but the need is even greater when some of the higher impact engagements are considered. Where the engagement from universities requires access to the school in a more substantive way or where universities open their facilities to schools the receptiveness needs to be

backed by real commitment and the management and logistics put in place. Several contributors commented on the impact that was to be achieved through school inward visits to universities but in their perception these had become more difficult to organise. Schools appeared to be having more difficulty in releasing staff and pupils and in managing the organisational logistics. There appear to be real or perceived barriers, especially where younger pupils are concerned. These are possibly more easily overcome where individual universities work with established structures engaged with schools such as STEMnet and the Science Learning Centres. It is also likely that where activities are co-ordinated within the university so that there are clear channels into the school they will be more receptive.

However, we know of examples where schools themselves are defining what they need and developing exciting programmes with a range of universities to support their pupils in STEM subjects. These examples show that meaningful partnerships can be formed and it is worth looking at a couple of examples in more detail.

Framwellgate School Durham
Head: Mrs. Joan Sjøvoll

Framwellgate School, Durham is a successful 11-18 comprehensive on the outskirts of Durham City. It is a Science College, Training School, newly designated National Support School and is a key partner in the newly-established regional Science Learning Centre.

The North East Science Learning Centre is built on the school campus. Framwellgate is a partner along with the five universities in the region (Durham, Newcastle, Northumbria, Teesside and Sunderland) and some local businesses. There is a lot of integration between the activities of the school and that of the centre. Universities can also take advantage of the coordinating activity of the centre in order to add to their outreach activities. For example, through a teacher – scientist network and a Kit Club for all school ages.

The school is not only a key partner but takes advantage of the centre's activities. For example, the NE climate change schools project has excited many of their pupils. Working through the National centre for excellence in teaching of mathematics, the schools spent a week focusing on 'mathematics and crime' in March 2008.

In particular, the school leads on a number of programmes aiming to increase engagement and participating in STEM subjects. For example, over the past three years, science expeditions have taken place, in, Egypt, Australia and South Africa. There are active science clubs, one of which is visiting CERN in Geneva. There are "science stars"; a group of high attaining science pupils who act as ambassadors for science and who, in return, participate in a bespoke pathway for entry to university to study science. These activities make Framwellgate a leading school in terms of STEM subjects with high aspirations for all students.

Just as universities provide outreach resource for many schools in their region, from the schools perspective, it is important to work with multiple universities in the region. Mrs. Sjøvoll said "working closely with universities has had a very positive impact on pupils and on staff. Working together we can align and coordinate our resources, efforts and expertise so that we can not only better raise aspirations for all our young people, but also develop teachers and the whole school workforce".

Simon Langton Grammar School for Boys, Canterbury
Head Teacher: Dr Matthew Baxter,
Head of Physics: Dr Becky Parker , MBE

Simon Langton Grammar School for Boys is a school community of nearly 1000 students and staff set in the Kent countryside on the outskirts of the city of Canterbury. The school applies innovative approaches to teaching and learning and none more so than the Langton Star Centre.

The aim of the Star Centre is to give students the authentic experience of research in physics with the potential for real new research. It is also there to enthuse physics teachers and students locally and Nationally. They have an amazing range of partnerships with universities and research institutes in the UK and internationally including Imperial College, Open University, University of Kent and the University of Oxford.

For example, they have established a National Cosmic Ray Grid. This is a project to put a small piece of the CERN Medipix detector into schools for them to use as a cosmic ray detector. This has involved collaboration with CERN, Professor Larry Pinsky from the University of Houston, Texas and NASA, the Open University and Surrey Satellite Technology. The Star Centre will run collaborative projects with students and training sessions for teachers.

Other examples include work with the Faulkes telescopes (sited in Australia and Hawaii) through an international collaboration of astronomers to develop opportunities for original science to come from Faulkes observing. In this case, students can steer the direction of their own learning and the telescope through remote controlled access. Thus, one student developed a project on observing a particular feature of galaxies and there is potential for further original research by the students themselves on exoplanets, asteroid rotation and supernova work.

The Head of Physics, Dr Parker, received an MBE and an honorary degree from the University of Kent this year for her work in encouraging young people into further study and careers in physics. The school produces a significant number of all the physics undergraduates in the UK. Dr Parker said ‘I believe that giving students access to and involvement in real physics research can increase participation both at ‘A’ level and at University.’

Continuing Professional Development

The provision of CPD in schools is vital in support of Science teaching. The recent Royal Society report on science teaching showed serious problems. In 2005/06 recruitment to teacher training courses fell short of government targets by 10% in science and by 18% in mathematics. These disciplines also had the highest drop out rates as compared with other sub-disciplines in teacher training (both in excess of 15%). In chemistry and physics the shortages are so severe and recruitment difficulties so harsh that many schools have ceased to advertise and instead seek 'general science' teachers. Therefore there is likely to be both a shortage of qualified teachers and a particular shortfall in the specialist areas of mathematics, physics and chemistry. To compound the problem 50% of science teachers that qualified in 1994 and 1995 were not teaching after five years. There is thus a combination of low entry and high churn. These characteristics of the workforce will correlate with the low availability of specialist science GCSEs and low continuity within schools, inhibiting pupils from following clear paths with known teachers. The Royal Society notes that specialist teachers produce higher levels of success yet the decline in the availability of specialist teachers has been evident almost continuously since 1991.

The distribution of specialist teachers of science is uneven. They are more likely to be found in the independent sector than the maintained sector and within the main stream maintained are more likely in grammar schools than comprehensives. They are least likely to be found in the FE sector. This may be related to the provision of science 'A' levels within the FE sector to which we refer later in the report.

Many universities are working hard to recruit to specialist science teacher training programmes and are also offering specialist support through CPD to both keep current the level of knowledge in science teachers and also to enable generalists to better cover the key specialist areas. The work of the Science Learning Centres is commendable in this regard and many universities have their own programmes. The Further Mathematics Network also has a CPD component with readily available lesson plans and course inputs purchasable from the network. The STEM partnerships hubs also offer useful advice to schools.

There is still a gap that needs to be filled in providing a complete and integrated level of consistent support to schools' science teachers. The initiatives that exist appear to do so in isolation.

Novel approaches are used to provide CPD support on-line and at a distance. There is also the need to ensure that facilities are available and many universities extend a welcome into their teaching laboratories for such CPD events. There is a tendency for these to be focused upon those institutions that are directly involved in teacher training and even within these institutions there can be disconnect between the education department and the specialist science departments. Some internal co-ordination may increase impact.

CHOICES AT AGES 14 – 16

The current pattern and disposition of subjects within the STEM domain at university level requires a very clear set of competencies and prior attainment before entry. The route through which both discipline specific prior knowledge is obtained, allied to the need for a sound preparation in mathematics, means that there is a very clearly articulated route into STEM. This clarity of route also presents potential difficulties if vital steps in the process are broken.

There is an argument regarding just how specific the needs are at university level and whether the focus, which is clearly linked to producing science graduates for science careers (including university post graduate research), is not too tight. There may be alternative routes for the scientifically informed rather than scientifically specialist with opportunities for later specialisation but this line of enquiry is not pursued here. Other constituencies may wish to debate this proposition at another time.

Choices of subjects taken with a view to GCSE entry at 16 are currently therefore an important prerequisite for further study in science. Consequently, attainment at this stage is important.

There are a number of crucial intervening variables that can influence the potential for success at this stage. What advice and guidance do young people receive? What GCSEs are available? What specialisms do the school support and with what facilities? How well qualified are the staff to both teach and enthuse students at this time?

Before addressing some of these issues from the university perspective it is worth looking at the scale of science at GCSE and some possible implications.

In 2007, there were 956,056 entries in double science GSCE and 760,299 entries in mathematics. In terms of number of pupils, 67% took the double science option (with 51% getting A* - C grades), 12% took single science and 8% took triple science (biology, chemistry and physics). Although entries in triple science increased from the previous year by between 4 -5 %, they still account for a relatively small proportion. The predominance of double science and its current volume can create an impression of a highly scientifically engaged cohort. However, the necessary underpinning for 'A' level is more readily facilitated by those who take triple science. Only 32% of maintained mainstream non-selective schools have pupils taking triple science GCSEs which rises to 73% for grammar schools. If there is to be an increased flow through from 'A' level to university in science subjects, then there is a need to extend the opportunity for those that wish to take triple science within the maintained sector. ,

The latest 2006 OECD survey – the PISA survey scores for 15 year old pupils - show the UK at 14th out of 57 nations surveyed in science subjects. However, this overall disappointing position is a mixture of much better

achievement at the higher end (levels 5 and 6) but lower achievement at levels 1 and 2. Perhaps this relates to the level of science teaching available in schools with triple science being available only to a few pupils and some pupils only taking one science GCSE.

The distribution of availability of GCSE provision in the sciences is largely out of universities' hands, though there are examples where if the availability is inhibited by a lack of qualified staff or available facilities universities can work with schools to seek to address these shortages. Thus, many universities are actively engaged with the provision of CPD for science teachers to ensure that they have the contemporary underpinning knowledge to support the curriculum (see earlier section). The Further Mathematics Network is effective in supporting the preparation of students and the underpinning mathematical ability.

Whilst ever there are differences in availability there will be inhibitors in the flow of potential students. At present, availability is the consequence of a series of decisions by different constituencies taken for unrelated reasons. The organisation of secondary education has a marked impact. Universities report quite different experiences in different localities dependent upon the pattern of secondary schooling. This situation may be eased or complicated by the introduction of diplomas. If diplomas can provide the underpinning body of knowledge to prepare for university entrance in STEM then the flow may increase and those areas in which there are current deficiencies may see the depth of provision enhanced. However, there is scepticism in the university STEM community about the ability of diplomas to meet the knowledge needs.

The time at which career choices are made and the influences brought to bear on such decisions is important. They are often made very early in the secondary cycle. The decisions that are made pre-14 on choice of subjects are pivotal. Universities already contribute to this age group and younger through a number of initiatives including their active participation in Aimhigher.

Their ideas on what careers they are attracted to are formed before they get to GCSE decisions. If this is the case then pupils need to be aware of the choices available to them, the options that are opened up and the options that may be being closed off. The information, advice and guidance that they receive at a very early stage is important. How good is this? A number of representations have been made that suggest that it is at best incomplete. Universities will fundamentally reap the consequences of such advice regarding STEM. Effective career guidance is needed prior to 14 and universities may have a role to play in ensuring that the local IAG community has up to date information on career choices and pathways for the sciences. There may be ways in which the University careers service dealing with graduate output could provide input to their colleagues at the early stage so that there is a degree of consistency and flow of careers information.

CHOICES POST 16

'A' levels are at present the main route by which pupils may progress to HE to study STEM subjects and thence to careers in science. Hence availability of 'A' level science provision across England remains important.

There are some foundation courses which enable pupils who do not have the grades necessary at 'A' level to get further skills with a view to employment or further study. One example of this is a foundation degree at the Kent Regional Resource Centre in life science laboratory technology and bio-manufacturing. This is run with a number of partners with the aim of increasing skills and employability.

Many of the reports referenced in the introduction were a response to the well publicised down turn in the number of pupils taking STEM subjects at 'A' level. Thus, following dips in the number of pupils taking maths and further maths in 1999 and 2000 these subject entries have been increasing since 2003 and have increased further this year. Since 2007, there has also been an increase in those taking physics 'A' level. However, the numbers of pupils taking biology, chemistry and physics 'A' levels were all less in 2007 than in 1997 despite these increases.

Universities have traditionally focused on outreach on this cohort of pupils as they are likely to be applying to university at the start of their second year of 'A' level study. Universities are also likely to have partnerships with secondary schools, sixth form colleges and FE colleges in their region with the aim of supporting widening participation and increased access to HE. Specifically in science, many university science departments have focused on outreach in order to increase the number of applications in less popular subjects, such as physics and those that are perceived as being hard. Specific problems have also been addressed by Universities. For example, the lack of sufficient teachers with expertise to teach further mathematics has led to further maths networks in many regions. There are currently 47 such centres covering all English regions. The tight geography of each centre provides an effective and workable network maximising access.

We have looked at the access to 'A' level provision depending on type of school. Thus, in 11-18 maintained mainstream schools in England, 94% out of 1712 schools have pupils taking at least one traditional science 'A' level (i.e. in biology, chemistry and or physics). In terms of sixth form colleges, of which there are 96, and in terms of grammar schools, of which there are 164, this percentage increases to 100%. However, within FE colleges only 62% of the 166 in England have students taking at least one of these traditional science subjects. Moreover, 38% of FE colleges do not have a single 'A' level entry in these science subjects. This in itself may not be problematic if pupils have free access to 'A' level provision in these subjects at other institutions in their regions. However, if the only route is via FE then there may be a lack of

opportunity for those not able to attend a selective sixth form. There may also be a problem with continuity in information, advice and guidance if students move schools at age 16. This will depend on the structure of secondary education within a particular region. We still recognise the need for aspiring and encouraging pupils to take up this provision where available, especially when we know it is perceived as being harder than other choices of study.

One approach to outreach and encouraging applications in physics has been taken within the South East region. Working together, six universities in the South East offering physics have been funded by HEFCE to work together to promote outreach, promote and support undergraduate provision and to collaborate in research in some areas of physics (www.sepnet.ac.uk).

We have also looked at 'A' level attainment as a function of type of school. We are aware that many students with top grades in science subjects come from selective independent schools. But what does the maintained sector look like? Unsurprisingly, grammar schools tended to have more pupils obtaining A and B grades with 65%, 71% and 65% in biology, chemistry and physics (2007). Sixth form centres also did well with 47%, 53% and 46% obtaining A and B grades respectfully in biology, chemistry and physics. The results from FE and the main stream maintained sector were similar in bioscience (34% versus 39% respectively) and in physics (41% versus 43%). There was a bigger difference in chemistry with FE only obtaining 38% A and B grades whereas the maintained sector as 47%.

DEGREE CHOICE

Universities have been as aware as any sector of the effect of the drop in pupils taking traditional 'A' levels with a consequential knock-on on the number of applications in, for example, STEM subjects. Universities also recognise that many pupils wishing to study medicine or veterinary science, have to take science 'A' levels and thus there is a further drop in the number of those converting from 'A' level study to non-medical STEM subjects at university.

We have noted the numbers of students who still obtain first degrees in STEM subject in the UK. In 2005/2006, just over 130,000 students obtained their first degree in a STEM subject from UK HEIS representing 42% of all first degrees that academic year. The break down is of interest and relevant to the Royal Society report 'A Degree of Concern'. 21% of these awards are in subjects allied to medicine and a further 21% in biological sciences. Engineering and computing make up 15% and 14% respectively whereas physical science and mathematics are 10% and 4% respectively. The rest is made up of medicine and dentistry, agriculture and veterinary science.

UUK publishes their 'Patterns of higher education institutions in the UK' report each year which includes analysis by subject[22]. Over recent years it has been computer science that has seen the biggest decline in applications at university level and the drop between 2005/6 and 2006/7 enrolments is 11%. This is in contrast to the latest positive report from e-skills on current and future jobs in IT and telecoms (Technology Insights, 2008. www.e-skills.com). As a consequence of the drop in science applications since 1997, some relatively small physical science departments in universities have closed leading to considerable publicity especially when a region of England may be left without HE provision in Chemistry or Physics. HEFCE and universities are now trying to address this through the strategic and vulnerable subject initiative.

Mathematics

We wish to continue to emphasize that mathematical skills and general numeracy underline many aspects of science, technology and engineering. Since the Smith report in 2004, there have been several initiatives to address this. Recently, Sir Peter Williams has reported on mathematics teaching in primary schools (www.standards.dcsf.gov.uk) and OFSTED have published their report on mathematics teaching more broadly in schools (www.ofsted.gov.uk).

It is evident that unless that there is a marked and consistent attention to the development of mathematical ability in prospective undergraduate students, the other aspects of the STEM agenda will continue to face difficulty. However, the STEM agenda is not alone; there are many areas where lack of general numeracy at university level is considered a problem.

For example, BBSRC (Biotechnology and Biological Research Council) found that only 9% of undergraduates in biosciensces had 'A' level mathematics although the subject itself was going through profound change and becoming more data rich and quantitative. Similar concerns are there in the social sciences as well as the more traditional physics, chemistry and engineering.

COMMENTS AND RECOMMENDATIONS

We recognise that there is a huge commitment from universities to the development of STEM. There are already a great number of initiatives underway both within individual institutions and through various relationships and partnerships. We applaud the commitment and our recommendations should be seen against this backcloth of activity. We also recognise the excellent practice in some schools and have given examples of this.

In undertaking this report, we have noted some issues regarding opportunities within schools to progress in science at different levels. First, we support the National Science Director in wishing to see that triple science GCSE is available to all within the maintained sector. We are not saying that this should be mandatory but that that all pupils, irrespective of school, should have access to such provision within the school system. Secondly, it appears that not all pupils within the maintained sector have access to the traditional science 'A' levels with those in FE colleges potentially being at a disadvantage. We suggest that this is investigated further to see whether there is equality of opportunity across England whatever the structure of secondary education post-16.

We have seen many examples of good practice and have summarised some of these in our report. We have seen that most universities are committed to addressing the need to recruit more undergraduates into STEM subjects and most are also engaged in providing active support through schools on this agenda. Thus recognition and action in this area is not a matter of controversy. However, we recognise from the overview that we have seen that more/more effectively could be done by universities in some areas.

We make recommendations in five main areas as follows:

(A) Institutional response

Recommendation 1: We recommend that universities formally recognise as institutions that such support – whether of aspiration or attainment – is part of their role in STEM subjects and not just leave it to individuals or individual sections of their institution. We recognise that there are many committed individuals but it is not always clear that the university as an institution is recognising their activity.

Recommendation 2: We recommend universities share their approaches more so that the dissemination of best practice can be more readily achieved. There is so much activity that each university should review how it undertakes this. Given the changing landscape in secondary and post-16 education, Universities will need to consider working as part of 'learning communities' to ensure that there is completeness of provision and that such communities are properly advised on the importance of the availability of routes into STEM at university.

Universities might wish to consider whether aspects of their leading research could form part of their dissemination strategy which may translate into more inspired pupils wishing to pursue science.

(B) More effective use of resources

Recommendation 3: We recommend universities seek to co-ordinate better internally to ensure that they maximise impact. This comes from recognition that not only are different universities undertaking a lot of activities but there is also a wide range of activity within many institutions. It is unclear whether all individuals involved are aware of the activities of others within their institution.

Recommendation 4: We recommend that Universities should also ensure that they maximise leverage from other activities by joining up their existing initiatives – such as those more generally aimed at widening participation

(C) Reviewing the focus of activities

Recommendation 5: We recommend that universities review their activities to get a balance between activities related to aspiration and attainment at different stages of a pupil's development

While recognising that universities will naturally wish to encourage those taking 'A' levels to continue scientific study as a recruitment activity, they need also to look at more generic aspirational roles that they can undertake, especially with younger pupils between 11-14 and at primary school .

As we have noted, there is perception that STEM subjects are in some way more difficult than other subjects. Therefore it is necessary to have young people highly motivated to commence a route at 14 which is widely perceived as 'difficult'. Motivation and excitement at the prospect of STEM and the opportunities it opens up must be matched by clear channels to entry without any perception of 'dumbing down' the content or level of science to which they aspire .

(D) Coordination of relationships with other universities, agencies and networks with similar aims

Recommendation 6: We recommend that universities make sure they work with other partners. Such partners could include other

universities in their region or other National or regional organisations such as STEMnet, or science learning centres.

(E) Joining up information, advice and guidance between schools and universities

Recommendation 7: We recommend that government gives thought to providing a mechanism to enable such an IAG pathway for all pupils.

From the standpoint of the pupil, they need to see a joined up approach to information, advice and guidance (IAG) around careers in STEM subjects and the choices they need to make in order to achieve their career aspirations. This will depend on information given in school or, in some areas, schools as some move at 16 to sixth form or FE College and information available in universities from both their recruitment and their career advisory sections.

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Annex 1 Letter from the Secretary of State

The Rt Hon John Denham MP

Secretary of State for Innovation,
Universities and Skills

Department for **Innovation, Universities** & **Skills**

Professor John Coyne
Vice Chancellor
The University of Derby
Kedlestone Road
Derby
DE22 1GB

11 June 2008

Dear John

INCREASING THE ROLE OF UNIVERSITIES IN RAISING STEM ATTAINMENT IN SCHOOLS

Following my speech to the HEFCE conference on 8 April 2008, I'm grateful that you have agreed – with Professor Julia Goodfellow – to look at one aspect of the higher education widening participation agenda which I consider of strategic importance to the UK. I hope this will, in turn, form a key part of the wider debate I am keen to see take place across all aspects of Higher Education. I am pleased you have already begun to discuss this issue with officials here in DIUS, and I welcome your initial thoughts scoping out areas for potential investigation.

The role of HEIs is critical in ensuring fairness in the opportunities available to young people in the maintained sector, and on which I see a need for universities to work more closely with schools in supporting improvements to teaching and also aspirations to take up STEM careers. I hope that if they can help strengthen school science, universities will contribute directly to the widening participation agenda.

I appreciate that the primary aims and characteristics of many of our world-class research institutions may not at first sight appear suited to the needs of young people, but the expertise, facilities and personal enthusiasm found in universities is a resource that is relevant and is already being tapped in helping enthuse schools and children about the huge benefits of HE.

Steve Smith will no doubt have some important messages for us about university links with young people across all disciplines, but I have a particular interest in STEM. There is much already happening where universities play a positive role, such as their staff taking part in the Science and Engineering Ambassadors scheme. But in looking to the future, I would like you to make recommendations on two key issues:

- What more can universities offer to enhance their impact on STEM for young people?

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- How can universities improve their existing involvement with schools?

I'm most interested in tangible signs that the whole HEI sector is being motivated to make this kind of outreach work a major plank of their business. I'd welcome your ideas on what would constitute success here, from the perspective of universities and also schools. On both of these questions, the usual measures around GCSE, A-levels, and applications to university will show differences in national and regional trends, and I'd like you to consider specifically how universities can more effectively help improve the outcomes in the following areas:

- Choices at 14 – 16, and the influence of double award vs triple science GCSE
- Choices post-16, the effect of A-level provision in physics, chemistry, biology and mathematics
- Degree choice, and the existing influence of HEIs over schools, especially on local communities
- The role mathematical capability plays in providing a strong basis for success in studying STEM at university

I am keen that you work closely with others in this area, particularly the work of Steve Smith on widening participation more generally, the current activities of Universities UK, the work of John Holman (national STEM director), BERR and DCSF.

I would welcome your initial thoughts by mid-July, which I appreciate is a challenging timetable. I'd hope you can then deliver your considered views by September. That timetable will enable me to take full account as I develop the future agenda for the Department.

JOHN DENHAM

Annex 2 Interim Response

JC/HL

15th July 2008

The Rt Hon John Denham MP
Secretary of State for Innovation,
Universities and Skills
Kingsgate House
66-74 Victoria Street
London
SW1E 6SW

Dear John,

Interim Report on Universities and STEM

We write as promised to give you an interim report on our work to encourage an increase in the role of universities in raising STEM attainment in schools. You were kind enough in your letter to note that an interim report by mid July was a challenging timetable and so it has proved. However it is challenging because of the wealth of information and engagement that has been forthcoming. Your commission of this piece of work in April certainly touched a chord within the sector and I am sure that you and colleagues will be pleased to learn of the extent to which we have been given generous support from all parts of the Higher Education sector.

It is clear to us that there is great concern across the sector that we must ensure that more young people are excited by the prospects offered by STEM subjects and the avenues that this opens up for them in choosing university courses and later careers. You will be re-assured that there is no sign of complacency in the universities, university groupings or learned societies with whom we have engaged. You will also be re-assured to know that there is a wealth of engagement in this area that is both broad and wide.

It is also clear that the widening participation agenda remains crucial and actively pursued across the sector. Whilst there is evidence that teaching students from less traditional or less well prepared educational backgrounds is both more expensive and more challenging when they are in university there is nonetheless a great concern to ensure that previously under-represented groups are engaged and recruitment from such groups is sought. No university can afford to waste talent and it is evident that talent can be found widely distributed across the population. However, ensuring that students are well prepared to succeed in their study before they enter challenging courses remains a difficulty for some.

In the case of STEM, in particular, there are added motivational and structural issues which might inhibit the flow of potential entrants more than in other disciplines. They have a reputation as more challenging disciplines in and of themselves within the university curriculum (perception is as powerful as reality in this regard), they build more fully upon the necessary pre-requisite of pre-entry specialisation than many

other disciplines (recent reports that A levels are harder might inhibit appropriate choices) and they are very dependent upon both the availability of appropriate sciences within the school system and the quality of that provision. This makes the role that universities may be able to play in supporting schools to strengthen sciences challenging. It is, of course, the responsibility of schools to be taking the initiative.

It is necessary to have young people highly motivated to commence a route at 14 which is widely perceived as 'difficult'. Motivation and excitement at the prospect of STEM and the opportunities it opens up must be matched by clear channels to entry without any suggestion of 'dumbing down' the content or level of science that they aspire to. The key question we still need to address in our next work is "What role can universities play in generating this excitement and motivation?" The crucial time frame is in the early stages of young people's academic development (probably post primary and pre 14). There are some difficult issues to address.

It is also necessary to have the opportunities available within the system to ensure that if motivation can be raised there are clear pathways open to the student to develop the interest into a meaningful pre university preparation. This requires appropriate sciences to be available within the school for GCSE or diploma level, properly resourced, engagingly taught and covering in appropriate depth the chemical, physical and biological sciences alongside strong mathematics. It also requires appropriate advanced level provision to be available to ensure a seamless progression in building up the competencies necessary for university entry. There are a number of challenges already evident in our early research that suggest that there are major structural issues in the availability of sciences (over emphasis on the double award) organisation of the school system (fragmentation post 16 with a particular lack of sciences in the colleges) and uncertainty regarding the depth of sciences, mathematics and engineering in the development of the new diplomas (at best little understood). These issues are particularly relevant in the context of widening participation and reaching into socio economic groups that remain under-represented in the university system in general and in STEM in particular.

To simplify the issue for our purpose here these under-represented groups will either be in a particular part of the school system or may already have left and need to be encouraged to re-enter education. Both groups face structural challenge. Those in education are likely to have been in schools with the double award and to have progressed to a local college rather than stay within a school. Those out of education are more likely to re-enter either through a university access course or through their local college. There is early evidence that the pattern of availability of science preparation pre-university may reinforce the difficulty that certain socio-economic groups have in accessing university level science.

We are concerned that there is a real structural challenge to be addressed but we have not been able within our current remit to do a significant mapping of the availability of sciences. We suspect that there will be marked geographical differences. We are trying to explore this a little further before we produce our final report. We suspect that there is little that universities can do directly to address the structural patterns overall though there may be information that can help universities to focus attention into areas of shortage or particular difficulty. This approach is already evident in some respects through the Further Maths Network.

We do identify that there is influence that the university sector can bring to bear on the resourcing of science in schools and in the knowledge, skills and attitude of science teachers. There is already a great deal of energy, initiative and imagination being produced widely across the sector to address this issue. We have been both astonished and heartened by the level of activity from universities and other HEIs at their own instigation and through the many initiatives that are led by other groupings (STEMNET, learned societies, Science and Engineering Ambassadors Scheme, etc.). These initiatives encompass both direct and indirect interventions. The direct go straight to the student whilst the indirect focus upon the school or more particularly the teacher.

The depth and breadth of activity is clearly evident with examples of many initiatives that are quite similar across many universities and others that are very specific to a local concern or a local link. What is less evident is the extent to which these are formally recognised within the mission and strategic intent of the university (as opposed to being led from within an initiative group or a department) and the extent to which commonalities across the sector are allowing both leverage of the impact, more effective co-ordination across regions to avoid duplication or the sharing of best practice. We shall be addressing some of the ways in which this might be done in the next phase of our work. We still have a number of formal meetings arranged with key constituencies as well as further analysis to complete on information that we have received from interested parties.

There is no doubt that support and development is required for teachers. The contexts in which they work may inhibit the kind of excitement in science that will unlock young people's potential. The issues to address relate to the availability of specialist science teachers (the recent report on the lack of specialist Physics teachers throws this into sharp relief), the prevailing pedagogy and engaging ways to teach science that make it accessible without losing its content or standards and the resourcing of science regarding access to specialist equipment. We are exploring the role that universities currently play in each of these domains to identify how better practice may be supported and leverage gained from the activities. It is important to recognise that willing and receptive constituencies will be necessary to make progress. It will be vital that schools are receptive to any approaches if university initiatives are to find fertile ground.

We shall be concentrating in the forthcoming part of our work on developing answers to your key questions outlined in your correspondence of 11th June. In particular we shall be focussing on any gaps in support, ways in which the support can be better tailored to meet current and emerging needs and how (and through what mechanisms) universities can improve their existing involvement with schools individually and collectively.

Throughout our work we have sought to ensure that we have been informed by those many interested parties with ideas to offer, programmes in delivery and policies being pursued. We shall be seeking further engagement within government departments as we shape the final recommendations to emerge from our study. To date we have focused upon gathering information from within the university sector and from those organisations very closely engaged with it. We anticipate that broader information and views will be sought in the next part of our work including other government departments.

In this interim report we hesitate to make recommendations for action until the full range of information before us has been considered and until we have the

opportunity to test responses to some of the direction of travel. However it is evident that this is an area in which there is both a willingness to engage on the part of universities and a real concern for the underlying issue it seeks to address.

We continue to work with enthusiasm and look forward to presenting our final report in September. We are receiving excellent input from across the sector.

Yours sincerely,

Professor John Coyne, University of Derby
Professor Julia Goodfellow, University of Kent

Annex 3 Acknowledgements and Contributors

We are grateful to a large number of people who have directly or indirectly contributed to this report. Below we list, the University responses that we received directly or from UUK.

We have had very helpful input from Professor John Colman (National Stem Coordinator), Professor Michael Reiss (Institute of Education, University of London), Professor Sir Brian Follett (Chair of the TDA), Dr Vicky Pryce (Chief Economic Advisor and Director General of Economics, BERR) , Peter Davidson Senior Innovation Adviser BERR/DIUS) , Nick Dusic (Campaign for Science and Engineering in the UK), Dr Yvonne Baker (STEMnet), Dr Becky Parker (Simon Langton School for Boys, Canterbury) and Ms Joan Sjovoll (Framwellgate School, Durham).

The data on GCSE, 'A' level and degree provision has been provided by DIUS at our request.

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Council for Industry & Higher Education	Richard A Brown Chief Executive	STEM High Level Strategy Group - KPIs - 5 February 2008 A review of the STEM skills supply chain by Hugh Smith - March 2007

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UUK (Continued)		University of Portsmouth University of Southampton University of Sunderland University of Surrey University of Sussex University of Teeside University of Warwick University of York

Annex 4 'A' level grades for traditional science subjects - 2007/2008

	Biology					
School Type	A	B	C	D	E	U
Mainstream M	19%	20%	21%	20%	14%	5%
Sixth Form Centres	24%	23%	21%	17%	11%	3%
FE	15%	19%	21%	22%	17%	6%
Grammar	40%	25%	17%	11%	5%	2%

	Chemistry					
School Type	A	B	C	D	E	U
Mainstream M	23%	24%	21%	17%	11%	4%
Sixth Form Centres	28%	25%	21%	15%	9%	2%
FE	16%	22%	21%	20%	15%	5%
Grammar	44%	27%	16%	9%	4%	1%

	Physics					
School Type	A	B	C	D	E	U
Mainstream M	22%	21%	20%	18%	14%	5%
Sixth Form Centres	27%	19%	21%	17%	11%	4%
FE	21%	20%	21%	17%	15%	6%
Grammar	41%	24%	16%	11%	6%	1%

First published September 2008
Department for Innovation, Universities and Skills www.dius.gov.uk
URN 190-09-SC-on