EDUCATION

EDUCATION POLICY STATEMENT: 09/02

SCIENCE IN SCHOOLS

INVESTING IN OUR FUTURE

Institution of MECHANICAL ENGINEERS

Young people with good science, technology, engineering and mathematics (STEM) skills are in demand. They are essential to the future of our society and economy. Lord Sainsbury, for example, stated that; "In a world in which the UK's competitive advantage will depend increasingly on innovation and high-value products and services, it is essential that we raise the level of our science, technology, engineering and mathematics (STEM) skills.[1]"

Yet there are many factors that militate against young people electing to study STEM subjects and thus pursue careers in related fields. There are many areas of action required if we are to motivate young people to study STEM and pursue related careers and the Institution is encouraged by the initiatives already undertaken by the government. However, the Institution urges the government to:

- **Fully fund the re-skilling of teachers** in science and mathematics;
- **Award UCAS points according to the level of difficulty** of A Level subjects (or equivalents, including Diplomas), including STEM;
- **Fund the provision of good quality science laboratories** and define "practical work" as "live" teacher demonstrations and hands-on pupil laboratory practical work.

Improving the world through engineering

SCIENCE IN SCHOOLS

DEMAND FOR STEM SKILLS

Society benefits enormously from scientific knowledge; from explaining how glasses can aid one's vision, to how to manipulate chemical compounds to produce the food we eat and the medicines we take when we are sick. Engineers take this knowledge and build on it to create solutions and technologies that underpin our health and our wealth. Equally, and of increasing importance, it is the role of the engineer to minimize our effects on our ecosystems and design infrastructure that is both efficient and safe.

The UK's high value-added economy is built on sectors with a high turnover and gross value added (GVA) per employee. High-technology industries such as power generation, oil extraction, telecommunications and aerospace play a key role in this; all are underpinned by engineering expertise based on scientific knowledge. Physics-based industries alone contribute more to the UK's GVA than the construction sector and provide employment to more than one million people: the total GVA of physics-based sectors stood at £70 billion in 2005, 6.4% of the output of the UK, comparable with the 6.8% GVA produced by the finance, banking and insurance sector[2].

The picture regarding demand for STEM skills is complicated, particularly when individual subject areas and sectors are accounted for. In a recent report the Department for Innovation, Universities and Skills (DIUS) noted difficulties in recruiting sufficient STEM qualified (degree or higher) employees and concluded that demand for STEM subjects is projected to see faster rates of growth than the national average over the decade to 2017[3]. More specifically, the CBI reports that, "By 2014 the demand for science, engineering and technology occupations is expected to have expanded by 730,000…[4]" Demand for people with STEM skills is not, however, restricted to STEM sectors; 92% of firms employ STEM-skilled people for their problem-solving and numeracy skills[4]. Put simply, demand for STEM skills will continue to rise over the next 10 years.

SUPPLY OF STEM SKILLS

If we are to meet the needs of our economy then we must maintain the supply of STEM-qualified graduates. The number of STEM-qualified graduates relies on the number of students enrolled on STEM courses at university and, clearly, the number of students studying STEM subjects at school. Hence, if we are to ensure a healthy supply of STEM-qualified graduates we must ensure sufficient numbers are enrolled and interested in STEM subjects at A Level, GCSE and Diploma.

"ABOUT 25% OF SCHOOLS FOR THOSE AGED 11 TO 16 DO NOT HAVE A SPECIALIST PHYSICS TEACHER."

SCIENCE IN SCHOOLS: THE KEY ISSUES

Triple science

All children are required to study science and mathematics up to Year 11 (Key Stage 4). At this stage the majority of children undertake Double Science GCSE which combines elements of Physics, Chemistry and Biology. This is not always a matter of choice: only 26% of mainstream schools offered Triple Science GCSEs in 2005–6, compared to 58% of science specialist schools, 66% of grammar schools and 72% of independent schools[5]. Indeed, independent schools account for a third of Triple Science entries and 50% of A* grades[6].

It is widely accepted that Triple Science helps young people better prepare for study and succeed at A level[4,7]. For example, young people who take Triple Science are 76% more likely to achieve grades A or B at A Level Chemistry compared to those who take double science[8]. More young people studying Triple Science could well, therefore, be a key way of increasing the number and improving the preparation of young people taking A Levels in the sciences with a similar knock-on benefit at university.

From September 2008, all pupils achieving at least level 6 at Key Stage 3 (of which there are about 250,000 each year[9]) have been 'entitled' to study Triple Science, although not necessarily in their own schools. In the same year, when overall GCSE entries decreased by 2.7%, numbers enrolled on GCSE biology increased by 35%, chemistry by 29% and physics by 29%[10].

Teaching

Teaching quality and supply are important. Ofsted reported that the quality of science teaching relates directly to the qualifications held by teachers; they also concluded that teachers' qualifications have a direct impact on pupil performance and their likelihood of continuing with science education[11]. This is reinforced by the Centre for Education and Employment Research which found that teachers' expertise in physics as measured by qualification is the second most powerful predictor of pupil achievement in GCSE and A-level physics after pupil ability[12].

Alongside the effect on student achievement, teachers' qualifications can have a negative impact on students' perception of the subject in question. An incomplete understanding and lack of confidence in a subject limits the ability of a teacher to provide deep and inspiring subject knowledge which can be transferred into the classroom. Simply put, young people are best taught science by teachers who are well-qualified in their subject.

Worryingly, there is a shortage of specialist teachers (with a degree or additional teacher training in the subject) in the sciences, most critically Physics[13]. About 25% of schools for those aged 11 to 16 do not have a specialist physics teacher; 20% of science teachers have a specialism in physics, 25% have a chemistry specialism while 44% have a biology specialism. Moreover, only 76% of mathematics teachers are specialists in the subject[14].

Despite some initial misunderstanding of the magnitude of the problem, the government is now implementing measures to address the quality and supply of science teaching in schools. For example, there has been emphasis recently on encouraging qualified professions to change career into teaching and a selection of Golden Hellos and bursaries are available for mathematics and science trainees[15].

Practical science

The practical element of science learning can be highly motivating. Lord Dearing captured this well in a House of Lords debate; "…in a survey pupils were asked which subjects in the curriculum were the most difficult. The answer was: maths, science and languages. They were asked: what would you do to improve things in sciences? The answer was: less listening, less copying notes and more big bangs. That is a true story. They wanted to do research in the laboratory.[16]" Similarly research suggests that the ability to carry out hands-on experiments, to enquire and investigate are key factors in generating enthusiasm for science in school[17].

However, in 1999 Ofsted estimated that 20% of school laboratories were so poor that it was directly affecting teaching[18]. In the same year the Royal Society of Chemistry estimated that a quarter of school science laboratories were unsafe or unsatisfactory and a further 41% were basic or uninspiring[19].

Activities as diverse as drama, web-searches, book research, computer simulations, video films of practicals, "live" teacher demonstrations and the more traditional class science practical activities have all been used as examples of practical science. While we would agree that all these, and similar, activities can play a role in STEM learning, "live" teacher demonstrations and hands-on laboratory practical work are essential for pupils to learn science appropriately. Reports exist of new laboratory designs which include extensive internet facilities and large screens but limited bench space, gas and electricity for practical work. Internet searches and video demonstrations, whilst valuable, should not be considered legitimate replacements for practical work. Similarly, there have been examples reported of the installation of unsatisfactory laboratories in new PFI-built schools. The main reasons behind this appear to be cost and health & safety[20].

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ONLY 26% OF MAINSTREAM SCHOOLS OFFERED TRIPLE SCIENCE GCSES IN 2005–6, COMPARED TO 58% OF SCIENCE SPECIALIST SCHOOLS, 66% OF GRAMMAR SCHOOLS AND 72% OF INDEPENDENT SCHOOLS.

School performance tables

School performance tables also play a role in creating a culture in which science and mathematics suffer. Some subjects are more difficult than others[21]. The difference in difficulty between subjects can be as much as 2 grades at A Level and one grade for the majority of GCSE subjects (up to one-and-a-half for ICT); at both levels STEM subjects are at the top end of the difficulty range, although this is more pronounced for A Levels.

Head teachers now run competitive businesses; it matters to them what their results are in the performance tables. Thus the school may well benefit from pupils choosing to take subjects that are likely to produce higher grades; pupils may also benefit as the UCAS points system treats all A-Levels the same, regardless of difficulty. Therefore, performance tables, like other incentives to perform and to inform, have unintended consequences. One side effect may be to damage the very subjects which are the most challenging and which we need more pupils to take.

GETTING GOOD SCIENCE BACK IN SCHOOLS: HOW SHOULD WE DO IT?

- **More positively promote Triple Science to able pupils**. Pupils who achieve an equivalent standard to Level 6 in national tests (SATS) should be automatically opted-in to Triple Science to encourage them to further their science education. An opportunity to choose the Double Science award instead would need to be made available.
- **Fully fund the re-skilling of teachers in science and mathematics**. We applaud the introduction of government targets against which recruitment progress will be measured. The supply of science graduates each year is, however, insufficient to make real progress against these targets (e.g. 2,400 UK physics graduates each year) in the short to medium term. For the foreseeable future we will need to properly fund and promote the training of teachers in mathematics and science subjects in which they were not originally qualified. The government has already introduced a scheme to encourage this but the financial support provides insufficient incentive.
- **Fund the provision of good quality science laboratories**. This should start by properly defining "practical work" as "live" teacher demonstrations and hands-on pupil laboratory practical work. All new build schools should have properly resourced laboratories that support this defined practical work. Existing facilities should be reviewed and brought up to a minimum acceptable level to support practical work.
- **Award UCAS points according to level of difficulty**. Students shouldn't be punished for choosing challenging subjects; they should be rewarded.

REFERENCES

[1] The Race to the Top; A Review of Government's Science and Innovation Policies; Lord Sainsbury of Turville; October 2007

[2] www.iop.org/activity/business/Publications/Physics_and_the_Economy/page_4388.html

[3] The Demand for Science, Technology, Engineering and Mathematics (STEM) Skills; Department for Innovation, Universities and Skills, January 2008

[4] Taking Stock, CBI Education and Skills Survey 2008; CBI; April 2008

[5] Incentives to Improve the Uptake of Secondary School Science; Press Release; 4 August 2008 (www.savebritishscience.org.uk/press/releases/yearlists/2008/pr040808.pdf)

[6] Campaign for Science & Education on the UK; Opinion Forum; Secondary Science Education; May2007

[7] Campaign for Science and Engineering Argues for Increasing TripleScience Provision; Press Release, 21 August 2008 (see www.sciencecampaign.org.uk/press/releases/2008/pr0908.pdf)

[8] Science and innovation investment framework 2004-2014: next steps; March 2006; page 47

[9] 'Bright Kids Should Study Triple Science GCSE', News Release, CBI, August 2008

[10] Campaign for Science and Engineering Argues for Increasing TripleScience Provision; Press Release, 21 August 2008 (see www.sciencecampaign.org.uk/press/releases/2008/pr0908.pdf)

[11] Incentives to Improve the Uptake of Secondary Science and Mathematics, CaSE, Press Release 4 August 2008

[12] Centre for Education and Employment Research, University of Buckingham, Physics in Schools and Colleges: Teacher Deployment and Student Outcomes, November 2005, p i. Commissioned by the Gatsby Charitable Foundation

[13] www.news.bbc.co.uk/1/hi/education/6722653.stm; also, www.guardian.co.uk/education/teachershortage and www.scenta.co.uk/careers/studying/cit/1725469/teacher-shortage.htm

[14] NFER (2006), maths and Science in Secondary Schools – The deployment of teachers and support staff to deliver the curriculum

[15] www.tda.gov.uk/Recruit/becomingateacher.aspx

[16] Lords Hansard, Volume No. 691 Part No. 81, Thursday 3 May 2007, www.publications.parliament.uk/pa/ld200607/ldhansrd/text/70503-0011.htm

[17] Real Science: Encouraging experimentation and investigation in school science learning; NESTA Research Report; November 2005

[18] Ofsted Annual Report for 1997/8, 1999

[19] RSC/CLEAPSS, Laboratories, Resources and Budgets, April 2004

[20] House of Lords, Science and Technology - Written Evidence, Memorandum by the Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS), July 2007

[21] Relative difficulty of examinations in different subjects, Report for SCORE (Science Community Supporting Education), June 2008, Robert Coe, Jeff Searle, Patrick Barmby, Karen Jones, Steve Higgins

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