A Good Year for Science Education – and better years ahead!

Dr Robert Kirby-Harris

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Over this past year there have been a number of significant positive developments in relation to science education: the "Next Steps" review of the Science & Innovation Framework; new programmes announced by HEFCE to stimulate demand for physics, chemistry, engineering and IT; the STEM Programme Report; additional funding made available for high cost laboratory subjects at university; and funding by DfES of the Careers from Science project.

The primary reason for this level of concern and concentration of new initiatives is economic. The UK needs to significantly expand its output of scientifically and technically trained young people if it is to compete in the global knowledge economy – and yet we have seen over a number of years stagnation or relative decline in numbers studying at university and absolute decline in numbers studying post 16 at schools and colleges. Our education system does not seem best placed to fulfil this key role; and along with these "economic system" failings we realise that we are not best serving our young people, especially young women and those from poorer backgrounds and some minority ethnic groups. These problems are particularly acute in physics education, which I will focus on for the rest of this article, but most of what I present will apply equally to chemistry and mathematics (and engineering at tertiary level).

There are a number of causes for this problem residing principally within the secondary system and its interface with higher education. The lead cause, supported strongly by the research evidence, is the profound shortage of qualified physics teachers. The majority of pre 16 physics teaching is being carried out by non specialists, and this is a dominant factor in young people not being enthused to study physics post 16. We need to greatly expand the numbers of qualified teachers, either through increasing the pool of new entrants to the profession or by providing suitable training for non-specialist teachers. The IOP has been working with the Training and Development Agency on a Gatsby Foundation funded initiative to upgrade non-specialist scientists and then support them through initial teacher education and their early years of teaching; and this project has successfully increased intakes by a significant proportion. We are also working with Government and other bodies to develop the physics diploma that would enable existing teachers to become qualified specialists. Continuous professional development and support are also major factors in retaining highly qualified and enthusiastic teachers. The IOP works with schools across UK to support teachers: running networks, providing updating courses, and recently launching a set of CD-ROMs for non specialists teaching in the early secondary years. Government and other organisations also contribute much, but it is clear we need to do far more and act in a more co-ordinated way, including providing significant resources and incentives for teachers and schools.

A second major cause lies with careers advice, which does seem to be very weak and misleading in general. The evidence indicates that physics graduates have excellent opportunities to undertake well paid and interesting work right across the economy, but this message is just not getting through to young people and those who influence them. The Careers from Science project aims to present the reality through a website and marketing materials. Career choices are clearly linked to subject choices and here the relative difficulty of physics is a problem. Recent evidence shows that students of similar ability taking some "soft" subjects gain two grade points over studying physics; this leads to students being steered away from physics because of individual university aspirations and school league tables. This "system failure" needs resolving through weightings or insistence on science performance in the School Accountability Framework, and in the short term students need to be made aware of the lower grade requirements for physics coupled with its higher earning potential.

A third more diffuse cause is cultural. The phenomenon of young people turning their backs on science is not exclusive to the UK, but we do seem to be performing badly even within this more general context. Yet the considerable challenges that the world faces over climate change and sustainable development, and the considerable achievements of science in improving our quality of life and our understanding of the world, should provide the stimulus for young people to study science and consider entering scientific careers. In conclusion, we should be aiming for a stimulating and well taught curriculum, exciting experimental work, and a broad range of relevant enrichment activity beyond the curriculum, within a rational educational system where young people have good information on which to base their choices. With this in place we should be able to increase the numbers of young people taking science over the coming years to the benefit of the economy and broader society.

Science education for all

Jenifer Burden
Co-director, Twenty First Century Science

"Science in schools must maintain its traditional and vital focus on preparing the most interested and talented pupils for science courses at university. At the same time, it must equip *all* students for what has been called "scientific literacy" or "science for citizenship."[1] This is the key challenge for our school science curriculum.

The need for change

After the introduction of the National Curriculum in 1989 the majority of young people aged 14-16 in England and Wales studied a "Double Award" Science course for 20% of their school curriculum, leading to two GCSE grades in Science.

During the 1990s it became clear that making all students follow the same curriculum was turning off too many students, but crucially also failing to provide the depth of challenge needed to stimulate those with a potential interest in more advanced study in science.

This experience reflected the inherent tension between meeting the needs of both our future scientists, and those who will not pursue a science-related career, which becomes more noticeable as students reach the age of 14.[2]

In 2002 growing evidence led the House of Commons Select Committee on Science and Technology Third Report: Science Education from 14-19 to state that: "A new National Curriculum should require all students to be taught the skills of scientific literacy and selected key ideas across the sciences. This core should form the basis of a wider and more flexible range of exam courses, reflecting the diverse interests and motivations of students." [3]

Following a large pilot programme, *Twenty First Century Science*,[4] the science National Curriculum was significantly revised for September 2006. *Twenty First Century Science* is now one of five sets of science GCSE courses available to schools in England and Wales.

Science for all: developing scientific literacy

A key innovation of the *Twenty First Century Science* is the GCSE Science course taken by all students, to develop scientific literacy. Much has been written about how to define scientific literacy, but clearly no-one can be said to be scientifically literate unless they understand some science – "what we know". A broad understanding of the main science explanations provides a framework for making sense of the physical world. However, it is also vital to reflect on the nature of scientific knowledge – "how we know": the practices that produce scientific knowledge, the kinds of reasoning used in developing a scientific argument, and the issues that arise when science is put to a practical use.

Thus the aim of developing scientific literacy "does not mean turning everyone into a scientific expert, but enabling them to fulfil an enlightened role in making choices which affect their environment and to understand in broad terms the social implications of debates between experts." [5] These are important ideas for both the future scientist, and other informed citizens.

Take as an example the recent public concern regarding potential risks from the MMR vaccine: what might be important knowledge and understanding for a concerned parent making this choice for their own child? A basic understanding of the functioning of the immune system is clearly required. But it was not a public lack of understanding of the immune response that precipitated the significant rise in parental concern and subsequent drop in measles vaccination uptake in 1998.[6]

More important in this case is some understanding of methods of data collection and limitations of any data, the distinction between a correlation and a causal relationship, the process of peer review, an appreciation of the regulation of medicine production, and an awareness of the need to balance benefits against risks. These are some of the ideas about the nature of science that students explore in the new GCSE Science course. Far from "dumbing down" of science these ideas can be complex and sophisticated, and are as crucial for future scientists as they are for the general public.

Science for the next generation of scientists

In the new curriculum most students are still expected to study science for 20% of their curriculum time. Thus alongside their GCSE Science course a student usually selects from a range of additional science courses. These courses are designed to be worthwhile in their own right, but also to prepare for more advanced study in academic or vocational science programmes.

For example, GCSE Additional Science provides an introduction to more theoretical ideas and concepts in biology, chemistry, and physics. This course reintroduces some of the intellectual challenge that was lost in the previous "one-size-fits-all" National Curriculum, and provides a stronger basis than before for progression to Advanced Level science.

Alternatively, learning in the GCSE Additional Applied Science course focuses on the mastery of technical skills and the use of these to solve problems well suited to young people who want to see more immediate practical uses of the knowledge and skills they learn. Students can build on their learning in this course to take science A-levels but are more likely to take an advanced applied or vocational course after the age of 16. Finally, students with a strong interest and aptitude in science may study three separate GCSEs in Biology, Chemistry, and Physics, which incorporate both the Science and Additional Science courses, plus further more specialised material.

This range of curriculum options provides all students with a grounding in scientific literacy, and appropriate routes to meet individual needs for future scientific study.

REFERENCES:

1 House of Lords Select Committee on Science and Technology, Third Report (2000).

2 Millar R and Osborne J (Eds) (1998) Beyond 2000: Science education for the future. London: Nuffield Foundation.

3 House of Commons Select Committee on Science and Technology Inquiry into Science Education from 14-19 Science and Technology Committee, Third Report (2002).

4 Commissioned by the Qualifications and Curriculum Authority (QCA) the Twenty First Century Science pilot involved over 75 schools from 2003-2006 (http://www.21stcenturyscience.org).

5 European Community (1995) White paper on education and training: Teaching and learning – Towards the Learning Society (White paper). Luxembourg: Office for Official Publications in European Countries. Paper presented at the National Association for research in Science Teaching (NARST), St Louis, 26-28 March.

6 In 2005-2006 84% of children in England had received the MMR vaccine by their second birthday (NHS Immunisation Statistics, England: 2005-06, Department of Health). The World Health Organisation recommends a 95% uptake in order to prevent outbreaks of the disease.

The Unkindest Cut!

Neil Roscoe

Head of Education, Institute of Biology

In a recent survey of school teachers and technicians conducted by the Institute of Biology, 60% of respondents believe that more practical dissection should be done in Science classes. Furthermore, 85% consider that the amount currently being done has declined compared to the levels in 1986 (when the National Curriculum and compulsory Science education in schools was first introduced.)

The reasons for the decline are difficult to quantify, but there are several possibilities. They include: perceived concerns around health and safety regulations and confusion over what is actually allowed; the high numbers of Science teachers working outside their degree specialism (and perhaps lacking the necessary biological skills) and the ease with which staff can now simply screen demonstrations using interactive whiteboard technology, rather than doing the real thing. Couple all this with the bad press the practice has encountered from those who are opposed to animal testing and it is easy to see how dissection in particular has suffered a multiple whammy in recent years. Should we be prepared to see this educational tool die out, or has the world moved into a technological age with simulations which no longer require it?

Dissection of whole organisms carried out in school Biology classes in Britain is now less common due to ethical concerns surrounding the fact that these organisms are specifically bred for the purpose. It is easy to have sympathy with this stance, but I would contend that whole organism dissection (particularly the rat) remains educationally valuable. Many Biology teachers would agree. Nowhere else can students get a sense of wonder in how all the systems of the body fit together.

Individual organ dissection survives in British schools today because it is less controversial. The animal has been killed anyway for food, so this removes the difficulty that it has been bred specifically to be dissected. Popular choices for this kind of practical include: pigs' hearts; lambs' kidneys and bulls' eyes. A "pluck" (heart and lungs of a sheep) is also useful when teaching mammalian ventilation.

Having said that, dissection is obviously not for every student and it remains best practice to allow students to opt-out of these kinds of activities as some students object on ethical or religious grounds or are simply just squeamish. Teachers should also always give students the opportunity to debate the issues and offer useful alternative activities to learn the same content. The survey suggests most staff do this.

Clearly in the survey the majority of teachers believe more dissection work should be done. This is hardly surprising because the "wow factor" and potential to inspire students with this skilful practical activity really should not be underestimated. The possibility that by being "switched on" by dissection classes at school might lead a student into a medical, bioscience or other scientific career further down the line, is unproven but likely. This is why we should seek to encourage the dissection of at least individual organs in Biology classes wherever practicable.