SCIENCE EDUCATION

MEETING OF THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE ON MONDAY, 27TH OCTOBER 2003

The science curriculum for schools is being adapted to meet the requirement not only to provide enough well-qualified scientists, engineers and medical professionals for the future, but also to develop a scientifically-literate general population which can intelligently debate a whole range of "science in society" issues. Improved communication through the formation of grass-roots partnerships between schools and the wider scientific world and eLearning, which could well play an increasing part, particularly in higher education, were also considered.

In discussion the following points were made:

In school science there was only one right answer. Examinations mitigated against open-ended questions. Science needed to be taught as a creative subject, but aspects not assessed were not taught. Science needed divergent minds but its teaching attracted convergent minds.

Many experiments were long with periods of dullness and did not fit well with the school time-table. IT simulations could provide an earlier, more realistic experience while an interactive system would safely promote curiosity.

In some ways the educational establishment was weighted against science. Science degrees were expensive and universities were cutting back. There were fewer science teachers and fewer A level students. The single science degree meant that if you were looking for a chemistry teacher you would be choosing from those who at age 19 had chosen to read chemistry. A more pluralistic science degree would provide a wider cohort.

The science education required for teaching could well be very different from that required for research and industry yet the degree content was the same for both. Teaching the evolution of scientific ideas would overcome many of the present shortcomings and dispel the notion that scientists were passionless, neutral and balanced beings. Risk and uncertainty were current concepts which ought to be addressed in the classroom.

The Curriculum

John Holman, University of York

Science has been part of the compulsory core school curriculum since the National Curriculum was introduced from 1989. What is the justification for making science compulsory in all state schools, alongside mathematics and English?

Science in the school curriculum has what Lord Jenkin has called a "dual mandate": to inspire and prepare both the minority of students who will be future science specialists and the majority who will not. This responsibility is echoed by Dr. Ian Gibson, MP, who commented in his select committee's report on science education that "we need to encourage a new generation of young scientists and to ensure that the rest of the population has a sound understanding of scientific principles"[1]. Since the introduction of the National Curriculum for Science there has been an increase in the total number of students taking science at GCSE, the culmination of the compulsory phase of schooling, but perhaps paradoxically, a reduction in the numbers wanting to take the study of science further, at least in the physical sciences. Thus, the number of GCSE science entries rose from 916 000 in 1990 to 1,234, 885 in 2002, but the number of entries for A level chemistry fell from 45,968 in 1990 to 36,648 in 2002.

Thus, we see an increase in the numbers of "generalists" – those who are studying science as part of a general education – but a reduction in the number of "specialists" – those who wish to take their study of science further, into A level and higher education. A number of studies have suggested that students find the current curriculum "rushed", "fragmented" and "irrelevant"[2], especially as they approach GCSE at the end of

[1] House of Commons Select Committee Press Release, http://www.parliament.uk/commons/selcom/s&tpnt37.htm

[2] For example, see Osborne J and Collins, S. (2000) *Pupils' and Parents' views of the school science curriculum*, Kings College, London.

compulsory education and begin to think about their options for further study. The challenge for the education system is to provide an appropriate grounding in "scientific literacy" for the generalists, while stimulating and whetting the appetite of young people to take their studies of science further. Meeting this challenge is partly a matter of getting the curriculum structure right, but the quality of science education depends more than anything else on the supply and professional expertise of science teachers.

Curriculum structure: *21st Century Science*

The shortcomings of the current science curriculum are most apparent at Key Stage 4 (GCSE). At present, about three-quarters of all students take a "double award" science course at GCSE, which is generally accepted as providing a suitable grounding for further study, for example at AS level. Yet among those students will be many who do not wish to take their study of science further, but who nevertheless need a science course that will prepare them to be informed citizens in a democratic society. In October 2000, the Qualifications and Curriculum Authority (QCA) commissioned a study from the University of York Science Education Group to recommend alternative models for Key Stage 4 of the national science curriculum. This study has, with QCA's backing and with funding from the Nuffield Foundation, The Wellcome Trust and the Salters' Institute, resulted in *21st Century Science*. This pilot GCSE course is under development at the University of York and the Nuffield Curriculum Centre and began in 77 pilot schools, with about 8,000 students, in September 2003. If the evaluation of the pilot is positive, this course could provide a model for a more flexible approach to GCSE science.

21st Century Science comprises GCSE specifications (syllabuses) supported by books, computer learning, new experiments and activities and a package of training for teachers. It features a Core Science course, studied by every student and designed to develop scientific literacy, together with optional Additional Science courses. Additional Science (General), when taken together with Core Science, offers progression to further study of science at AS level; Additional Science (Applied) offers progression to vocational or pre-vocational courses to prepare for a science-based occupation.

In creating the Core Science course for *21st Century Science*, the development team have addressed the question: "What kind of science do ordinary people need to know, in order to equip them for life in a world dominated by science and science issues – such as the implications of stem cell research, the safety of GM crops and the security of electricity supplies?" The response has been to create a course built on twin foundations. First, it is important to know some basic scientific principles, and we have identified 16 "science explanations" – the big ideas of science, such as the gene theory of inheritance and the nature of chemical change. But we assert that scientifically literate students need not only scientific knowledge, but also an understanding of the way science works – what we describe as the "ideas about science" – the way scientists use data and look for correlations, the way they make and use theories and the way society uses scientific data to make decisions.

For example, one of the nine Core Science modules is called Air Quality. It uses the context of air quality, particularly with reference to the effect of motor vehicle emissions, to introduce "science explanations" on *chemicals and chemical change*, using the simple molecules – CO, CO_2, SO_2, NO etc – involved in air pollution to introduce the key idea that a chemical change involves rearranging the atoms of one molecule to form another. The Air Quality module also introduces "ideas about science" on data and its *limitations*, in the context of the measurements that air quality scientists make, and *correlation and cause*, in the context of investigations to establish whether a disease such as asthma has a causal link to air pollution by nitrogen oxides.

21st Century Science will be externally evaluated before any decision is made to extend its lifetime beyond the two-year pilot, but if it is successful it will show one way of providing a science curriculum that is more appropriate to all young people, whether or not they want to continue their study of science beyond the age of 16.

Professional development for science teachers

More appropriate curriculum structures will help, but ultimately better science education lies with the teachers themselves: they hold the key to students' motivation and achievement. The kind of changes called for in *21st Century Science* can only be delivered by an appropriately trained and motivated teaching force. This was recognised in Lord Jenkin's report *Science in Schools*[3], which advocated better quality continuing professional development (CPD) as a means to improve the skills and motivation of the profession. This call was taken forward in Sir Gareth Roberts' review which recommended that the Government "improve science teachers' access to, and take up of, subject related CPD, which will benefit their teaching and also act to improve retention"[4].

In December 2002, the DfES and the Wellcome Trust announced proposals for a national network of Science Learning Centres, to take the lead in transforming science education through the professional development of science teachers. The purpose of the Science Learning Centres will be to improve the recruitment, retention and professional skills of science teachers and technicians through a systematic programme of CPD with a science focus. On October 16 2003, the winners of the contracts to establish and run the Science Learning Centres were announced. The National Centre, for the whole of the UK, which will be funded to a total of £25 million from the Wellcome Trust, will be at York and run by the White Rose Consortium of the universities of Leeds, York and Sheffield with Sheffield Hallam. There will be nine Regional Centres for England, funded by the DfES to a total of £26 million.

The Science Learning Centres are now

[3] *Science in Schools:* report of the House of Lords Select Committe on Science and Technology (March 2001).

[4] SET for Success: the supply of people with science, technology, mathematics and engineering skills. The report of Sir Gareth Roberts' Review (April 2002). Recommendation 2.6.

working together, under the chairmanship of Sir Gareth Roberts, to determine a national strategy for science teachers' CPD, in time for the opening of the Regional Centres in October 2004 and the National Centre in 2005. At the heart of this strategy will be the objective of reconnecting teachers with their subject by keeping them up to date with developments at the frontiers and helping them acquire new skills and ideas for inspired teaching. The commitment of over £50 million to this initiative is a mark of the strategic importance of science education to Britain, and represents an unprecedented opportunity to make a lasting difference to its quality.

SCIENCE EDUCATION

The Importance of School-Scientist Partnerships

Dr Eric Albone
Director, Clifton Scientific Trust

The Challenge facing School Science

Science[1] is an intensely human, intensely creative, enterprise. Science dominates our lives and presents society with tremendous opportunities and tremendous challenges. It is exciting and perplexing, disturbing and enlivening. What it is not, is dull.

Yet dull is how school science is seen by many young people. It is a damning indictment that the Commons Science and Technology Committee reported[2] in 2002 that "Many students lose any feelings of enthusiasm they once had for science. All too often they study science because they have to, but neither enjoy nor engage with the subject. And they develop a negative image of science which may last for life".

Similarly, Sir Gareth Roberts[3], in his 2002 Report to HM Treasury highlighted the need to attract the brightest and most creative minds to become scientists and engineers and expressed concern that while the numbers of scientific/technical degrees had been rising, those in physics, mathematics, chemistry and engineering had fallen significantly, a trend which threatened the UK's competitiveness. The Report stressed the need to improve the relevance of the science curriculum to students in order to capture the interest of students (especially girls) and to better enthuse and equip them to study science,

In a different context, the Lords Science and Technology Committee Report Science and Society[4] underlined the crisis of public trust in much scientific information and pointed to the need to develop a culture of dialogue between scientists and the public. It emphasised the importance of science teaching in schools to equip all students for citizenship, and referred to the value of developing partnerships between schools and working scientists.

Student Engagement

Engaging the enthusiasm of the student is pivotal. The culture of excessive central measurement and assessment in education, undertaken with laudable aims, has in practice not only undermined the professional autonomy of the teacher and inhibited school-based curriculum innovation, but has killed the love for learning in many young people. If students gain no real enthusiasm for what has been learnt, they have gained very little of lasting value however well they may perform in tests.

Student enthusiasm and commitment derive very powerfully from students gaining a personal sense of the real life relevance of their school experience, and of their own participation in and ownership of their learning. Grass roots partnerships between schools and scientists have tremendous potential to bring this about.

Through such partnerships, students can set their classwork in context by encountering at first hand something of the challenge of science as a human activity, where answers are always provisional, where uncertainty abounds, where "there are no answers at the back of the book", and where teamwork and creativity are rewarded. How often is school science thought of as a "creative subject"?

Peak Experiences in Science?

In the context of music education, John Sloboda[5] has drawn attention to the great importance for student motivation

[1] Science is used throughout in a generic sense to include not only engineering and medicine, but also contexts in which science relates to ethical, economic and other concerns.

[2] HoC Science and Technology Committee *Science Education from 14 to 19* HC 508-1, July 2002

[3] Sir Gareth Roberts' Review to HM Tresury, *SET for Success; The Supply of Poeple with Science, Technology, Engineering and Maths Skills* April 2002

[4] HoL Science and Technology Committee *Science and Society* HL 38, Feb 2000

[5] John Sloboda, Musical Expertise. In Ericsson, K.A. & Smith, J. (eds). Toward a General Theory of Expertise. Cambridge University Press. (1991)

of “peak experiences”, deep and rewarding personal experiences which have emotional as well as intellectual content.

Are such quality, motivating, peak experiences possible in Science? Teachers know that they are. School-Scientist Partnerships can contribute greatly here by:

- challenging students to experience their school learning in open-ended, real-life contexts
- encouraging students to think for themselves and to question
- respecting and valuing the students' contributions.

A powerful example of this is provided by the student response to the Japan 2001 Science, Creativity and the Young Mind Workshop which we devised as part of the Japan 2001 Festival. Hosted in Bristol, post-16 students from schools across Britain and Japan lived and worked together for a week in small UK-Japanese teams with expert guidance on open-ended science-related explorations, experiencing at first hand science as more than a compendium of “right answers”. Through science they also learnt from each other's way of thinking and of doing things. UK students were selected on “widening participation” criteria and in both countries two thirds of the applications were from young women.

The science achievements in the week were remarkable. Thus, NASA, with whom our Space Science Team were in daily video link exploring hypotheses concerning the origin of the Martian volcanoes could write:

“All felt the excitement of the real life scientific investigation and were amazed at the students' initiative and hard work. The model demonstrates effective collaboration among diverse cultures... More importantly, it demonstrates that, given an exciting challenge and necessary resources, young people will far exceed everyone's expectations!”

But even more telling was the student response. The following quotations are taken from our Evaluation Report.

“When at school, I was learning the science without being able to apply it; now I know what real science is like; I love it!”

“I managed to do a written report and presentation on a subject I knew nothing about with people I did not know, and yet to enjoy myself at the same time. I feel so proud to have taken part. I will never forget it.”

“It has changed my attitude a lot. I thought the Japanese were lovely people and I have realised there is so much to learn about the world.”

“At the beginning of the week, communication was a problem, but now it has been overcome and everything is exciting.”

“It has made me realise how many differences we all have, yet we all have so much in common and can enjoy our differences instead of having conflicts.”

We are now working with support from the Embassy of Japan and others to develop continuing UK-Japan School-Scientist Partnerships.

School-Scientist Partnerships

In July 2002, a survey of all Bristol LEA maintained schools seeking teachers' views showed that although very little was currently in progress, 92% of the 34 schools (from Nursery upwards) who responded felt such links would be of great or significant educational value, and 94% of schools asked to discuss possibilities in their school. Partnerships were seen to be of particular value in motivating pupils and in encouraging them to question. The most valuable mode of partnership would be with scientists working/talking with students in a continuing relationship with the school.

A number of organisations are currently seeking to build bridges between schools and the world of science and technology. One example, the Science and Engineering Ambassadors Scheme, is much to be welcomed in encouraging more scientists and engineers to work with schools; some 3,700 SEAS are now registered nationally. In the future the new Science Learning Centres will be in a position to play an important role in further facilitating such partnerships.

The closest approach to our own work is that of the Teacher Scientist Network in Norfolk. Like us, they stress the importance of working with the teachers to evolve creative partnerships from within the school, rather than delivering schemes to schools.

In building continuing School-Scientist Partnerships, we recognise the diversity of schools and see each partnership as being a unique exploration in what is possible in a particular school situation. Our task is to help the teacher and the scientist to work together to develop their own creativity in ways which fit their circumstances, and to network outcomes so that other teachers and other scientists can share good practice. Training to prepare the teacher and the scientist is of crucial importance.

We are currently developing an innovative Creative Science CPD Course to equip Primary Teachers to work with scientists in creative partnership. We have also developed models for very effective Primary Science Days. The most recent example involved staff from the Bristol Royal Infirmary working with sixty Bristol inner-city primary pupils and their teachers in ways which had an impact on the continuing teaching and learning in their schools.

Moving Forward

We see a major and largely unexploited opportunity to make a real difference to pupil attitudes to science through the development of a network of grass-roots School-Scientist Partnerships. The following are three key areas in which Government could at little cost greatly raise the profile of such partnerships within schools.

- Give real encouragement to academic scientists to become involved by giving genuine incentive. At present such activities do not count in the Research Assessment Exercise, and academics derive no benefit from becoming involved. Indeed often they are discouraged from taking part.
- Give more encouragement for industrial scientists to become involved, perhaps by instituting an “Investors in Education” award, similar to the “Investors in People” award.
- Give more encouragement to schools to become involved by raising the profile of such activities in OFSTED's inspection criteria, and by giving schools much greater encouragement to be pro-active in this area.

UK eUniversities Worldwide Limited

Sir Anthony Cleaver

UK eUniversities was established at the end of 2001 by the UK Government as a company to make the best of UK higher education available online anywhere in the world. It is not a university itself as students receive degrees from whichever university has developed the course they are studying. As a result, the university is responsible for all academic matters and the degrees awarded are subject to QAA regulation.

UKeU has three main responsibilities. First to develop and make available a top class electronic learning environment, or software platform, capable of dealing with thousands of students across the world. Secondly, UKeU works with universities to ensure that courses are developed to make good use of the platform and that the quality of the electronic aspects is high – UKeU has its own Committee for Academic Quality. Finally, UKeU provides an international sales and marketing capability for the recruitment of students overseas.

The first course became available in March 2003 and is a postgraduate certificate in open and distance learning, developed by the Open University and the University of Cambridge. A further 20 courses are now either under way or open for enrolment in Autumn 2003 or early next year.

While most of the existing courses are postgraduate, UKeU will be providing courses at foundation, undergraduate and postgraduate level, as well as Continuing Professional Development courses. Our focus is in seven main subject areas: business and management; science and technology; health; English language; teacher training; law and environmental studies.

UKeU is also charged with three specific initiatives on behalf of Government - the eChina programme, a collaboration between HEFCE and the Chinese Ministry of Education to provide in-service teacher training in China; the development of courses intended specifically to contribute to the "widening access" agenda in the UK and the establishment of an eLearning research centre, in collaboration with the Universities of Southampton and Manchester.

In its first 21 months UKeU has:

- developed the first version of its learning environment, in partnership with SUN Microsystems who are also a shareholder in the company with significant enhancements leading to the main version in Spring 2004
- established a portfolio of over 20 courses contracted with 18 UK universities and a pipeline which should double this number over the next two years
- established a global service support infrastructure, in partnership with Fujitsu, which provides support 24 hours a day, 7 days a week across the world
- established local market presence through our international business managers in Dubai, Hong Kong, Singapore, Malaysia, Brazil, South Africa, China, South Korea and India
- supported students studying in 36 countries across the world.

Given the challenges faced by science education in our schools, UKeU believes it can provide assistance in a range of areas. For schools, its platform could be used for continuing professional development courses and subject update modules for science teachers. Over time this and its range of science courses will create a national accessible library of science modules and teaching material. This can be supported by online discussion forums for science teachers, while the stock of science teachers could be increased through the use of conversion courses.

At university level, UKeU will provide a range of science courses. Already available are masters degrees in biomedical science, bioinformatics, geographical information systems, computer science, and environmental management, with specific focus on coastal zone management, energy management, renewable energy and environmental toxicology and pollution monitoring. Over time, UKeU could provide the vehicle for quality training and research methods, for new postgraduates, and the opportunity to develop the concept of an electronic "PhD", enabling the supervision of PhD students working remotely from their supervisor.

More generally, the ability to provide science modules at every level available online anywhere, anytime will make it possible for scientists both to remain current in their discipline and also to extend their range of understanding. Anyone interested in learning more could consult the UKeU website at www.ukeu.com or contact Jill Padley on 020 7932 4401 (jpadley@ukeu.com).