The Save British Science Society

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SBS 02/05

Preparing young people for life in the twenty-first century

SBS memorandum to the House of Commons Science & Technology Committee's Inquiry into Science Education from 14 to 19

1. SBS is pleased to submit this response to the Committee's Inquiry into science education between the ages of 14 and 19. SBS is a voluntary organisation campaigning for the health of science and technology throughout UK society, and is supported by 1,500 individual members, and some 70 institutional members, including universities, learned societies, venture capitalists, financiers, industrial companies and publishers.

2. We begin by outlining the principles on which we believe the education system should be built, before detailing some of the problems that currently exist within the system. We support the conclusions of the report on ***Science Teachers*** issued by the Council for Science and Technology in 2000.[i]

Amazement, knowledge and understanding

3. Science education is important for four principal reasons. First, and fundamentally, a civilised society is one in which the citizens are able to explore knowledge and understanding for its own sake. Second, a modern democratic society works best when its members can make informed choices. Third, the education system is a training ground for future generations of researchers in the science base, which is the bedrock of the economy. Fourth, learning about science, and especially mathematics, also gives training in ways of thinking that are useful in many other fields.

4. These four principles should underpin the system of scientific education in the UK, from the earliest years of primary school to the education and training of doctoral students. Science education should encourage the spark of creativity, which is just as essential to scientific progress as it is to progress in any other field of endeavour.

5. It can only do so by including a sufficient element of basic factual knowledge. In later life, basic facts may seem so obvious to most of us that we cannot remember learning them, but a full education demands that they are indeed learned.

6. Because of these interlinking principles and requirements, policies for science education should be viewed as a whole, not decided piecemeal for each different age group, with little reference to what precedes and follows each stage.

Tensions between teaching future scientists and those who will not practice science

7. The school science curriculum must balance two separate aims. It should educate the next generation of scientists, at the same time as preparing those who will not go on to study science at higher levels, but who will be prepared for active participation in a modern democracy only if they have a grasp of what science is and how it works.

8. The tension between these two desires has created significant problems in recent years, but only because the tensions are exacerbated by other problems, such as a shortage of enthusiastic teachers.

9. In essence, the tension between teaching a science specialist and science generalist is a creative one, and much of the basic material required is the same for both. For example, a need for an elemental understanding of how experiments work (for example the need for a control group) is common to both the budding scientist, and the budding citizen who wants to understand newspaper reports of field trials on genetically-modified crops, or studies of a link between MMR vaccines and health problems in small children.

10. Problems arise because of other issues, such as the difficulties of performing practical, experimental work in schools. Other ways must be found to learn about analysing empirical evidence, and this may potentially disadvantage the budding scientists more than it disadvantages other pupils.

Teacher shortages

11. The single biggest problem with science teaching in schools is that of recruiting and retaining high-quality, enthusiastic, motivated staff. A survey last year showed that 35% of mathematics teaching posts, 39% of technology posts and 26% of science posts remain unfilled.

12. In physics, between 1993 and 1998, across the UK, there were 1.856 fewer graduates training as secondary school teachers than would have been needed to fill existing vacancies, and posts created by the death, retirement or other loss if physics teachers.[ii]

13. Following the introduction of new training salaries and starting bonuses for physics teachers, the number of recruits increased in 1999, but in 2000, it had still fallen by 66% compared to 1993.[iii]

14. The Education Bill that is currently before parliament does nothing to address this issue in a serious and sustained way.

15. Teachers are not as badly paid as other professionals working in science education, such as university lecturers. Nobody can pretend that school teachers are well paid by comparison with what the same person could command in other occupations in the open market, but it seems likely that there are other significant barriers to the recruitment and retention of sufficient high quality teaching staff in the sciences.

16. This is not a new problem and a body of disparate work exists examining individual aspects of the issue. For example, it is some years since it was suggested that a majority difficulty in recruiting mathematics and physics teachers was that the satisfactions provided by teaching were not those sought by specialists in the physical sciences, and that it was necessary to broaden the range of potential applicants.[iv]

17. Nor is the problem unique to the UK. As early as 1986, France was training only 60% of its requirement for mathematics teachers, and in New Zealand 5% of schools had been unable to recruit qualified and trained staff in physics. In parts of Australia, 21% of physics classes were taken by teachers "whose qualifications comprised minimal or nor content studies, and no curriculum studies in the class subject".[v]

18. In 1989, the House of Commons Education Committee foresaw serious problems with the recruitment and retention of science teachers. The Committee believed that "the overall demand for teachers will be higher than that assumed by [the Government]," and that "the assumption that recruitment…in shortage subjects [specifically the sciences] will be 20% above current targets is distinctly optimistic" because "increased competition for school leavers…[will mean that] teaching will attract less than its present share".[vi]

19. SBS advocates that the Government should sponsor a detailed, quantitative study designed specifically to identify the factors that attract people into teaching, and those that discourage them to train or encourage them to leave the profession. No such large-scale research base currently exists to our knowledge, and an evidence base is essential to properly informed policy making.

The effects of double science

20. Most pupils no longer study individual scientific disciplines for public examinations at the age of 16. Instead, they study combined science. The theoretical advantages of this approach include the fact

that it allows the majority of young people to gain a fundamental scientific understanding and appreciation, without the need for equally in-depth knowledge of chemistry, physics and biology. It also allows future scientists to understand the cross-disciplinary nature of science, and does not encourage children to see barriers between individual disciplines.

21. In practice, however, the current situation falls far short of this ideal, as many pupils are taught various parts of the curriculum by teachers who are not qualified in the appropriate subject matter.

22. At Key Stage 4, only 33% of people expected to teach physics have a bachelor's degree in the subject, and 29% do not even have an A-level in physics. In chemistry, fewer than half of teachers have an appropriate degree and 14% have not studied chemistry to A-level standard. Among biology teachers, 61% have a degree in the subject, but 16% have not passed A-level biology.[vii]

23. Moreover, of those who enter teaching training with some level of qualification in their subject, the sciences have a very high proportion of people with lower class degrees. Although the data are somewhat out of date, figures presented in 1997 but collated earlier show that 38% of teacher training entrants in physics had a third class degree "or below," with 37% in mathematics, 34% in chemistry and 15% in biology, compared with just 5% in history, and 7% in both English and geography.

24. The effects on pupils of improperly or inadequately qualified staff are all too evident on young people: a group of university students described to SBS how some of the teachers who had taught them a couple of years earlier were "unenthusiastic or, more usually, simply unqualified to teach the material for which they were responsible".[viii]

25. The same group also felt their schools had been unable to provide adequate information about scientific careers, partly because their careers advisers were unenthusiastic about science, and partly because of the huge demands placed on their teachers.

26. Few, if any, of these problems can reasonably be blamed exclusively, or even principally, on schoolteachers themselves. It is unreasonable to expect people to teach subjects in which they are inadequately qualified.

27. Sufficient resources should be available that a student studying for GCSEs in science can be taught by at least one specialist in each of the three core disciplines of biology, chemistry and physics. This may require co-operation among local schools.

Confidence of teachers

28. Partly because they are not always qualified in the subjects they are required to teach, many teachers lack confidence in their own ability to teach the material for which they are responsible.

29. For example, at Key Stage 4 (GCSE level), only 50% of teachers who teach the "Physical processes" part of the curriculum (which roughly equates to physics) say that they have "a lot of confidence" in their ability to teach the material.[ix] In "Materials and their properties" (chemistry), 60% say they have "a lot of confidence" and in "Life processes and living things" (biology), the figure is just 52%. The low figure for biology is despite the fact that a higher proportion of science teachers have degrees in biology than have degrees in chemistry or physics, and despite the fact that biology teachers have, on average, degrees of higher classes.

30. One of the reasons why even trained biologists may lack confidence in their subject material is that modern biology moves forward very rapidly, with high profile developments in areas like genetic modification and stem cell research.

31. It is for this reason that SBS has advocated the introduction of sabbatical periods for teachers to spend time in universities or other laboratories, or in some other activity that can reinvigorate their knowledge and enthusiasm for their subject. Reciprocally, scientists and engineers from industry, universities and elsewhere should be encouraged to spend time in schools, passing on their experience, knowledge, enthusiasm and skills to a new generation.

The curriculum after GCSEs

32. The academic curriculum after the age of 16 is narrower in most of the UK than in the rest of Western Europe and America. Students are strongly encouraged to choose exclusively between the arts and the sciences at the age of 16.

33. Whether or not it is true, students perceive that A-levels in science subjects are harder than those in the arts and humanities. With increased pressure to succeed in exams, it seems likely that many students are influenced in the choice of A-levels by the perception that science and mathematics are more difficult to pass than other options.

34. The proportion of A-level students who have chosen to study three arts and humanities has held steady at roughly 50% of the cohort since the early 1960s, while the proportion studying three sciences has fallen dramatically, from about 45% in 1962 to about 15% in 1995. The shortfall has been made up of students choosing to study a mixture of arts and sciences.

35. These trends suggest two conclusions. Students increasingly want to study a broad mixture of subjects, but a decreasing proportion is fully prepared to enter science courses at university. For example, a chemistry lecturer at a well-known British university found that none of his class of undergraduates had the simple arithmetical skills required to dilute a solution of known concentration to a different specified concentration.[x] This supports the Select Committee's suspicion, voiced in its announcement of the current

inquiry, that the mathematical content of the school curriculum is being diluted.[xi]

36. For years, SBS has advocated the introduction of a system more like the French baccalaureate, in which students study both some sciences and some arts and humanities, and in which their studies in one or the other are sufficiently in depth that they are fully prepared to enter university. Since most students studying for A-levels now enter the higher education system, this is an important consideration.

37. Recent changes in the system of A-levels, whereby students study more subjects in the lower sixth and specialise more in the upper sixth are welcome in principle, but have not proved entirely successful in practice. A broader-based curriculum, incorporating an appropriate degree of specialisation, can only really be achieved through an integrated system like a baccalaureate.

38. SBS has welcomed discussions in the Welsh Assembly about the possible introduction of a baccalaureate in Wales, but warned that if the project goes ahead in isolation, without some parallel developments in England, confusion about parity between the baccalaureate and the A-level syllabus could disadvantage some students.

The relevance of the science curriculum

39. The Select Committee, in its notice of the current inquiry, reiterated a common observation: many people believe the science curriculum lacks relevance to the everyday lives of pupils and parents.

40. Insofar as this is true, it is partly a feature of the entire school curriculum: most parents and children do not need to speak French as part of their everyday lives, the Battle of Hastings is of little relevance to them, and the formation of ox bow lakes is of minor concern to working families.

41. That these things have little direct impact to the everyday life of most pupils does not make them irrelevant, any more than it is irrelevant to study Shakespeare or the underlying causes of the fall of the Berlin Wall. Why then should we insist on the entirely utilitarian nature of the science curriculum?

42. What people seem to mean when they complain of a lack of relevance is that the science curriculum does not adequately explore the developments that really do occur in everyday life and are reported in the media, such as genetically-modified foods or the risks of inoculation with the measles, mumps and rubella vaccine.

43. This is one reason that SBS advocates (in paragraph 31), giving teachers the opportunity to spend sabbatical periods refreshing their knowledge, and why we have advocated elsewhere the extension of the ethos behind the numeracy hour.

44. The numeracy strategy has worked in primary schools by giving teachers structured support and materials to assist in teaching parts of the curriculum with which many feel a lack of confidence. The same approach could assist secondary school teachers in their efforts to teach up-to-the-minute developments in science, which are reported in the media, which are seen to have direct relevance to people's lives, and which, if taught well, could be the gateway to excitement, enthusiasm and understanding for many young people.

Practical work

45. Practical experimentation is an essential part of learning about science. A good science education in school depends both on pupils being allowed the opportunity to conduct their own experiments, and on their being able to watch larger scale demonstrations, where it is inappropriate for individual children to undertake particular procedures (such as adding reactive substances like potassium or sodium to water). Such practical work captures the imagination of children, and can excite them about science.

46. In its report on ***Science and Society,*** the House of Lords Select Committee on Science and Technology expressed concern about the decline of practical work in school science classes.[xii]

47. In its follow-up report on ***Science in Schools,*** the Committee explored further the reasons for this decline, which is believed among much of the scientific community to be largely due to regulation. In fact, only two commonly-used experiments have been formally removed from the curriculum in the past 30 years, both involving benzene, which is a highly dangerous compound.

48. However, the interpretation of Health and Safety regulations is unquestionably hindering the conduct of practical work in schools. In the words of the House of Lords Committee, " health and safety regulations, if they do not actually ban experiments, nonetheless affect adversely the way in which they can be carried out".[xiii]

49. In its response to the Committee's original report, the government denied that regulation was preventing the conducting of practical classes in schools. While this may have been strictly accurate, it was not considered a helpful comment by members of the House of Lords Committee.

Vocational education

50. Over the past decade or more, new vocational qualifications, such as National Vocational Qualifications and Technology Education Certificates, have been broadly welcome additions to the educational landscape.

51. This is especially true given that the concept of the apprenticeship has declined as the economy has changed, and as the job market has shifted away from traditional occupations.

52. However, there remains some confusion as to the precise purpose of some qualifications, and in particular the meaning of their nominal equivalence to academic qualifications.

53. For example, there is a feeling among many university lecturers in mathematics that the system is unfair to students who enrol in the higher education system with a GNVQ that includes the nominal equivalent of an A-level in mathematics. In many cases, this supposed equivalence cannot be justified, and the students are not adequately prepared for the mathematical education they will receive as part of their university degree. They have been misled, their work consistently suffers, and they are unable to take full advantage of the educational experience of being at university.

54. The problem would be solved by greater clarity in what the various qualifications are genuinely supposed to represent, and in the insistence that qualifications that purport to have equivalence do in fact contain the appropriate content.

55. Vocational qualifications are valuable and worthwhile in their own right, and they do not need to devalued by the pretence that they are the same as academic qualifications of they are not.

February 2002

Notes and references

[i] ***Science Teachers: A report on supporting and developing the profession of science teaching in primary and secondary schools,*** Council for Science and Technology, 2000.

[ii] ***Physics teacher supply: Current issues facing secondary education,*** Institute of Physics, 1999 [IoP Policy Paper 991].

[iii] ***Physics Today,*** October 2000, p.13.

[iv] Smithers, A. and Hill, S. ***Recruitment to physics and mathematics teaching: A personality problem?*** Research Papers in Education, Volume 4, Number 1, pp.3-21.

[v] ***The shortage of mathematics and physics teachers,*** Department of Education, University of Manchester, 1988.

[vi] ***The supply of teachers for the 1990s,*** Second Report of the House of Commons Education, Science and Arts Committee, Session 1989-1990 [HC 208-I].

[vii] Figures supplied by the Institute of Physics.

[viii] ***Issues Concerning Students in UK Higher Education,*** SBS 2000 [SBS 00/09].

[ix] Dillon, J. and others (2000) ***A study into the professional views and needs of science teachers in primary and secondary schools in England,*** King's College London.

[x] SBS Newsletter, Winter 1998, p.2.

[xi] House of Commons Science & Technology Committee, Press Notice Number 7 of Session 2001-2002.

[xii] ***Science and Society,*** House of Lords Select Committee on Science & Technology, 3rd Report, Session 1999-2000 [HL Paper 38].

[xiii] ***Science in Schools,*** First Report of the House of Lords Select Committee on Science and Technology, Session 2000-2001 [HL Paper 49].