

Evidence from the Royal Society of Chemistry to the House of Lords
Select Committee on Science & Technology on Science Teaching
in Schools

1. The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of over 43,000 members worldwide and an internationally acclaimed publishing business, our activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public. The RSC, either on its own or with others, commissions research projects into aspects of education where evidence is apparently not available from Government, but is, in the RSC's view, in the public interest.
2. **The current situation relating to teacher deployment and subject specialism**

This is covered in the DfES sponsored NFER report 'Mathematics and science in secondary schools: the deployment of teachers and support staff to deliver the curriculum' which builds on earlier findings such as Chemistry Teachers (RSC 2004) (<http://www.rsc.org/Education/Policy/Supply2004.asp>) and the Parliamentary Office of Science and Technology Technical Report 88 (December 1996) which even then highlighted future shortages of qualified teachers in the sciences.

The NFER report

During the academic year 2004–05, NFER investigated the deployment in mathematics and science departments in one in four maintained secondary schools in England. The evidence was collected via a postal questionnaire to departmental heads and teachers of mathematics and science; a postal and telephone survey of support staff who assist in these departments; and case-study visits to 12 departments, deemed by their local authority to exemplify good deployment practices in mathematics and science.

The report indicates that only a quarter of UK secondary school science teachers have a chemistry specialism and less than a fifth have a specialism in physics. This is in contrast to 44% of science teachers with a specialism in biology. In addition, the survey found that 8% of those teaching science are non-specialists or are principally teachers of other subjects.

Table 1: Specialisms* and experience of all teachers teaching science according to departmental heads *Mathematics and science in secondary schools: the deployment of teachers and support staff to deliver the curriculum*

Members of science departments

Teachers with a specialism in:

Biology	44%
Chemistry	25%
Physics	19%
Other science	5%
Non-science-related subject	2%

Members of other departments

Teachers who mainly teach other subjects teaching science	6%
---	----

*Specialism was defined as 'holding a degree in the subject or specialising in the subject in initial teacher training.

The data also showed that the imbalance in the representation of biology, chemistry and physics specialists was unevenly spread across schools. Teachers with a degree in chemistry or physics were more widely represented in 11–18 schools compared with 11-16

schools. Also, schools with higher than average GCSE results and lower than average numbers of pupils eligible for free school meals tended to have a higher proportion of teachers with a science degree.

Table 2: Proportion of departments without any specialists in biology, chemistry and physics

Specialism	All schools (%)	11-16 schools (%)	11-18 schools (%)	Other schools (%)
Biology	1	1	0	0
Chemistry	7	12	4	2
Physics	16	26	10	6

The results show that there are some schools without a single appropriately qualified chemistry or physics teacher and a substantial number in which the majority of Key Stage 3 and Key Stage 4 science lessons are taught by biologists or those without a mainstream science qualification.

A further concern is the fact that the age profile of science teachers is unbalanced towards the high end. This will have serious implications for the continuity of passing on the craft of the classroom.

3. Attracting science teachers to the profession

There can be little doubt that the various initiatives such as training bursaries and 'golden hellos' have been successful in attracting people into science teaching. There remains, however, the major problem that recruitment remains supply led rather than demand led, that is more biology graduates enter initial teacher training than do physical science graduates whilst the evidence from the report in Section 2 above indicates that biologists should be a minority of the entrants.

The figures for 2005 are:

Chemistry	575
Biology	996
Physics	428
Combined Science	1012

Historical data for chemistry are at www.rsc.org/images/4TeacherTraining_tcm18-38626.pdf.

Some measures are being taken to increase the numbers of teachers with appropriate qualifications and/or training to teach physics and chemistry. The Physics and Chemistry Enhancement courses funded by the TDA have started to increase the pool. The proposals in the 'Science and Innovation Investment Framework 2004-2014: next steps' (March 2006) to increase the % of science teachers with a physics specialism from 19 to 25% by 2014, and those with a chemistry specialism from 25 to 31% are laudable, but short on detail. Whilst it is true (6.19 p44) that 'there is a good supply of relevant science CPD' it is unsurprising that with respect to the regional Science Learning Centres that take up on these courses has been slow with limited results so far when these providers are both new entrants to the market and there is no entitlement for science teachers to undertake subject specific CPD. (The RSC has not noticed any appreciable slacking in demand for its subject specific CPD in recent years).

The proposals (Box 6.2, p45) to develop and pilot a CPD programme leading to an accredited diploma to give existing science teachers without a physics and chemistry specialism the deep subject knowledge and pedagogy to teach these subjects effectively and to remit the Schools Teachers' Review Body to advise on whether such people should receive an incentive are welcomed. However it is unclear how

Headteachers and schools will be persuaded to release teachers to train, who will provide the training, the nature of any accreditation and the demand from the teaching force for training. There is also no consideration of how any of this is managed – from development to implementation. The RSC suggests that experience from the TDA enhancement courses strongly favours involvement of the professional bodies.

4. Teaching Science

The RSC will comment here only on the importance of specialist teaching, the role of the practical in teaching science, and on the relative difficulty of science subjects at GCSE and A-level.

Ofsted has commented on the positive correlation between the subject knowledge of teachers and the proportion of excellent/good lessons as measured by the inspection criteria. It is imperative, therefore, since there is clear evidence from the NFER report that much science teaching is carried out by non-specialists, that steps are taken to provide subject specific CPD for science teachers. Whilst the recent announcements about a diploma are a step in the right direction, until there is an entitlement for science teachers to engage in subject specific CPD, progress will be limited.

There can also be little doubt, from Ofsted and other evidence, that practical work in school science has suffered for two main reasons:-

- a) the drivers for teachers to obtain good results in external assessments in years 9, 11, 12 and 13 has meant there has been teaching to the test, spending more time than previously on revision and seeing non-assessed practical work as something that can be reduced.
- b) the formulaic nature of GCSE assessment has led to a narrowing of the type of practical work undertaken.

Recent changes to the science curriculum at GCSE for first teaching in September 2006 have led to an increasing emphasis on 'How Science Works' and the provision of courses both for those who are to be informed citizens in a scientific and technological society and those who are to be future scientists.

The RSC is clear that all these changes require practical work in its widest sense – investigation, experimentation to confirm known facts, handling of a wide range of data, including ICT, and working in teams. What is unclear is the role of the Qualifications and Curriculum Authority (QCA) in monitoring the Awarding Bodies to ensure that assessments reflect the Programme of Study or KS4 and its emphases.

There are many existing schemes designed to help generate enthusiasm in young people for science subjects. Indeed the recent DfES STEM Mapping exercise indicates that there may be too many and they may be too disjointed. There are, however, other factors that may inhibit choice, if not enthusiasm.

There has been clear evidence from matched pair analysis for over 10 years, from the Dearing Review of 1996, through the work of ALIS and the Curriculum, Evaluation and Management Centre at the University of Durham that both GCEs (A-level) and GCSEs in Science subjects are more difficult than many others. Thus students may well realise that if they need particular grades or UCAS points for entrance to higher education then chemistry or physics may not be the best choice. The QCA has addressed the issue of standards over time but has not addressed the issue of cross-subject comparability.

A further limiting factor on choice is the ignorance within the education system about the careers (and rewards) that can be achieved from a study of science, both within

and without science. This was recognised in the Science and Innovation Investment Framework 2004-2014 by the promise to establish a careers from science website under the auspices of the Science Council. Despite sizeable financial contributions from the RSC, and the Institute of Physics, the Royal Society and the Science Council, government has failed to offer any support to realise this project.

5. School accommodation and resourcing

Classroom practicals form an integral part of many science courses. Teachers are encouraged to include them in their teaching by both examination specifications and national schemes of work (guidelines which help schools implement the national curriculum). In addition, studies have shown that practical and investigative work has a marked positive effect on pupils' enjoyment and learning of science.¹

Although the UK has an excellent record in international comparisons in school science, a succession of reports have highlighted concerns about both the science curriculum and the facilities and resources available for science teaching.^{2,3} In 2003, the RSC decided to commission its own study into the current state of school science laboratories. Given the importance of classroom practicals in enhancing pupils' experience of science, the RSC was worried that a lack of good facilities and modern equipment in schools may be turning young people off pursuing the study of science. It was also anxious that these factors might discourage science graduates from taking up a career in teaching.

The RSC asked the CLEAPSS School Science Service (the Consortium of Local Education Authorities for the Provision of Science Services - an advisory body supporting the teaching of practical science) to undertake an investigation into whether these concerns were justified. The work was divided into two main projects; the first ("the Lab Project") looked into the current standards of science laboratories and resources and the levels of budgets required to make improvements where necessary. The second project ("the Resources Project") set out to determine the cost of providing apparatus, resources and chemicals needed, per pupil, to provide an effective science education. Research was then carried out to see how this related to actual provision made in schools. In April 2004 the final report was published, entitled 'Laboratories, Resources and Budgets'.

CLEAPSS sent questionnaires to every maintained school in England. Half of the schools in each of the 148 Local Education Authorities were sent a questionnaire relating to laboratories, the other half received one relating to resources and budgets. High levels of return for both surveys (42% on the Lab Project and 26% on the Resources) give high confidence in the results and provide an indication of the importance that schools place on this matter.

The results of the Lab Project make unsettling reading, with only 35% of school laboratories in the sample rating good or excellent. 41% were rated as basic and uninspiring, and an alarming 25% were rated as unsafe or unsatisfactory. Teachers also reported that, on average, one additional laboratory per school is required to

¹ *Students as 'Catalysts' in the classroom: the impact of co-teaching between science student teachers and primary classroom teachers on children's enjoyment and learning of science*, C. Murphy, J. Beggs, K. Carlisle, J. Greenwood, *International Journal of Science Education*, 26 (2004) pp1023-1035.

² Ofsted Annual Report for 1997/98, 1999; *Set for success. The supply of people with science, technology, engineering and mathematical skills*. The report of Sir Gareth Roberts' Review for HM Treasury, London, April 2002; *Science Education from 14-19. Third report of Session 2002-02 of the Science and Technology Committee*, House of Commons, London, July 2002; *SBS Survey of Secondary School Science Teachers*, SBS (The Save British Science Society), London, January 2004.

allow all science lessons to be taught in a laboratory. This equates to an under-provision of at least 3,518 laboratories.

This means that, when pupils are in a science laboratory, their experience is unsafe, unsatisfactory or uninspiring for 66% of the time (and this does not include the 13% of the time that they are not in a laboratory at all).

Problems were also brought to light regarding the preparation areas that support science teaching and the storage and preparation space available to science technicians.

The research clearly showed that significant work needs to be done to bring many school laboratories, and the associated areas, up to a standard that will promote a positive learning experience to science students. This evidence provided RSC with a strong case to lobby the Government for such improvements.

Laboratories	Number in sample	% in sample	Number estimated for all maintained schools in England
Excellent	280	5%	1,315
Good	1,641	30%	7,770
Basic (uninspiring)	2,262	41%	10,695
Unsafe/unsatisfactory	1,386	25%	6,560
TOTAL	5,569	100%	26,340

The cost of implementing the improvements required is substantial; if all issues are addressed at once, the total finance needed is estimated to be in the region of a staggering £1.38 billion. This represents the total cost to upgrade to a good standard only.

Description of required improvement	Cost
Upgrade all unsafe/unsatisfactory laboratories to a good standard	£361m
Upgrade all basic laboratories to a good standard	£321m
Build sufficient new laboratories	£510m
Provide sufficient fume cupboards	£41m
Upgrade all preparation areas to a good standard	£89m
Extend all preparation areas	£24m
Provide sufficient dishwashers	£6m
Minimum cost of lift provision (to carry equipment between floors when laboratories exist on more than one level)	£28m
TOTAL	£1,380m

Although the Government has committed £2.2 billion in 2005-06 to the 'Building Schools for the Future' initiative - which aims to bring all school buildings in England up to a modern standard by 2015 - none of this money has been ring-fenced for laboratories.

The results of the Resources Project indicated further shortfalls in funding. Over 90% of schools who responded to the survey judged that the finances allocated were inadequate to sustain an effective level of science education. In some cases the situation was so severe that schools were not able to fully meet the requirements of the National Curriculum (especially in ICT) and practical work was being cut down.

According to the findings, the average amount made available to science departments in the 2003-04 financial year (in maintained schools) was just £9.89 per pupil. This is

only slightly above the £9.40 average reported in a survey from 1998⁴, indicating that the increase in funding has not even kept pace with the rate of inflation (despite the rising cost of chemicals exceeding the inflation rate).

The low average amount per pupil is not the sole concern highlighted; there is also a surprisingly wide range within this sum – from £0.64 per pupil to £71.43. The authors of the report found it difficult to find justification of such extremes. There is a great worry that, at the lower end, the impoverishment of the curriculum is likely to affect pupils' motivation and interest in continuing with the study of science.

The Resources Project also investigated the cost, per pupil, of providing the equipment, chemicals and biological materials required to teach science effectively. The estimates included an 'essential' list of resources and a 'desirable' list (the latter includes items necessary to teach science post-16, but which also enhance the curriculum in Key Stages 3 and 4).

Annual cost per pupil, 11-16	Classes of 24 pupils		Classes of 30 pupils	
	Essential	Essential + desirable	Essential	Essential + desirable
Estimated cost	£20.58	£17.28	£22.22	£30.75
Shortfall based on survey finding	£11.80	£20.36	£13.44	£21.97

There are just under 3 million 11-16 year old pupils in English secondary schools – around half of these are in classes of 24 and the rest in classes of 30. This means that science departments need approximately a further £37 million per year to provide the essential resources for teaching science; equivalent to an additional £10,000 per science department.

The survey also quantifies substantial shortfalls in post-16 work.

The final report was sent to Ministers, government departments, the science education community and all secondary schools in the UK. The results of the report have since been validated by the Ofsted (Office for Standards in Education) Chief Inspector's report for 2005.

The full *Laboratories, Resources and Budgets* report is available at www.rsc.org/Education/Policy/Laboratories2004.asp.

6. Teachers' Continuing Professional Development

There is a general misconception that teachers are entitled to subject specific CPD. This is not the case, although the recent draft standards for teachers from the TDA require subject specific CPD. If there was an entitlement then more teachers would have the opportunity to improve their subject specific knowledge and practice.

Dr Colin Osborne
June 2006

⁴ *Science teaching and resources: 11-16 year olds. The Survey Findings*, P. Ramsden, *Education in Science*, 180 (November 1998), pp19-21.