THE ROYAL SOCIETY

Increasing uptake of science post-16

Report of a Royal Society conference held on Friday 10 March 2006 at the Royal Society, London

July 2006
ISBN 0 85403 626 1

excellence in science

ISBN: 0 85403 626 1

Report written by Hannah Hyam

Editor: David Montagu

Designed by: Franziska Hinz

Contents

Foreword

Professor Patrick Dowling CBE FREng FRS, Chair of the Royal Society's Education Committee

This conference arose as a result of a combination of factors:
(i) the Society's deep concerns over the dramatic decline, ongoing since 1991, in the numbers of young people opting to pursue A-levels in the physical sciences;
(ii) a conviction that, consistent with the government's desire to strengthen the science base, firm positive action must be taken to reverse this decline;
(iii) recognition that there is no single, quick or easy solution; and
(iv) a sense of a new mood of shared belief between the science/education communities and government to address this decline collaboratively.

The multiple strands of thinking contained in the report reflect both the comprehensive consideration of the issue and the valuable contributions made by all those who took part in the conference. In particular, I wish to express my thanks to the speakers for their stimulating presentations and accompanying papers, which provided thoroughly refreshing perspectives.[1] We have preserved the variety of recommendations suggested at the conference in their entirety, to reflect the wealth of ideas expounded at the conference. We hope that this thinking will help unite the many forces in science education around purposeful, cohesive and coherent action, and the Society itself will be considering how to take some of these forward, in partnership with others, where appropriate.

1 The original conference papers and handouts are available to download from the Society's website at: **www.royalsoc.ac.uk/education/14-19Education**

Some encouraging progress soon became apparent. Less than two weeks after the conference, on 22 March, the government published new and precise commitments to raising participation, performance and progression in science at all stages of primary and secondary schooling and to increasing the numbers of specialist science teachers.[2] In so doing, the government began to address directly a number of the recommendations from the conference. Even so, reversing the 35%, 22% and 13% overall decreases that have been recorded in, respectively, physics, mathematics and chemistry A-level entries over the past 15 years is going to require concerted action to make good these commitments.

The Society is conscious of the fact that while A-levels are the most common route into higher education and, accordingly, a career in science or indeed a whole range of other professions, there are other valuable and challenging post-16 qualifications in science. It will pursue an evidence-based approach in its consideration of the whole range of qualifications and pathways available for training future generations of scientists and engineers.

We would welcome any comments that you may have upon reading this report, particularly in relation to the recommendations for action and research; please email these (education@royalsoc.ac.uk) or send them to us at the address given on the back cover of the report.

2 HM Treasury, DTI, DfES, DoH 2006. *Science and innovation investment framework 2004–2014: next steps*. London: HMSO.

Executive summary

This summary is divided into three distinct parts, which derive directly from issues raised at the conference.

(i) Overview: this presents the key overall messages arising from the presentations and discussion at the conference.
(ii) A list of actions.
(iii) A list of research recommendations upon which some of the actions depend.

1 Overview

1.1 The importance of science

Why do we need to increase uptake of the sciences at A-level? Evidence shows that these qualifications may offer many young people significant personal benefits, that they are crucial for the future competitiveness of the UK economy, and that our education system is not fully promoting equal opportunities in these subjects. In addition, the speed with which young people mature beyond 16 means that engagement with science after this age can yield significant advances in their understanding of the subject in relation to their adult roles as UK and global citizens, their personal decision-making in an increasingly technological world, and their appreciation of their cultural heritage. Although the importance of the sciences is recognized by the public, government, industry and even young people themselves, persistent decreases in the popularity of chemistry and physics have been recorded despite an increase in the overall number of 16 year olds continuing into A-level studies. As we enter a period of decline in the secondary school population, this situation may get worse and increasingly impact on the numbers of students taking the sciences, and subjects which rely on the sciences, in higher education. In today's education market, the future of these subjects in schools, colleges and universities is dependent on healthy, consistent levels of demand among young people. Any further erosion of these subjects will place our science-based economy in serious risk of being over-reliant on expertise from overseas, and lacking the capacity to lead and innovate.

1.2 The murky pool of talent

One of the most difficult questions to ask when considering increasing uptake of A-levels is where we may expect that uptake to come from. Significant 'losses' to science occur all through the education system, but particularly at 16, 17 and 18 where young people can and do exert choices that will have a powerful effect on their immediate future. We remain too ignorant about where and why these losses occur to be able to target those young people who could and should continue with science post-16, but who currently turn away from it. This ignorance also poses a serious threat to our understanding of how the persistent flow of reforms in education, demographic changes, and public opinion, will impact on the popularity of the sciences.

1.3 Teachers, teachers, teachers

Teachers are the largest single source of variance in learning other than the students themselves. Therefore the uptake of science and mathematics post-16 will depend to a very great extent upon the availability of well-qualified specialist teachers pre-16. The government has failed to reach its initial teacher training (ITT) targets for science and mathematics each year for the past decade, and there are no accurate trend data about the numbers of new and existing teachers with different science specialisms. With retirements among science teachers over the next 10 years expected to be at least as high as the average number of retirements among all secondary school teachers (estimated to be between 33% and 40%), government will have to invest heavily in professional development and/or alternative sources of recruitment for subject specialists if shortfalls against its targets persist, and if it is serious about reversing the declining popularity of science post-16.

1.4 Change, progress and a unifying strategy

The government has been exceedingly busy pursuing change in the name of progress within the education system, and particularly in science. Examples of this include: a new strand of science GCSEs in 2006 and rising emphasis on applied science in the curriculum; the Primary and Secondary National Strategies; the specialist schools and academies programme; the national network of Science Learning Centres; and packages of financial support for trainees in shortage subjects. It is too early to assess the impact of these reforms on uptake of science A-levels, but it is fair to say that they have not been developed and implemented with that particular purpose in mind. Openly tackling sometimes unpalatable questions regarding the provision of the three separate sciences at GCSE level; financial incentives for science teachers; ring-fenced funding for science in schools (particularly with regard to laboratories and equipment); relative difficulty of A-levels; and a strategic careers advice service, must be a priority for the government. Uniting the large, diverse and enthusiastic science education and science communities behind common goals such as increasing the uptake of science A-levels is the job of government, and the duty of many organizations that depend on the UK's future success in science and engineering. At the same time, many in the community seem to feel that while the pace of change may be intended to support teachers, it is in fact distracting them and those organizations that support them from following their own professional judgements regarding the quality of learning they provide. New initiatives must be supported by compelling evidence, drawn from international comparisons where appropriate and possible. Further, the links between research, policy-making and their interface with classroom practice must be strengthened.

1.5 An evidence base: combining the research agenda and school know-how

While there is a need for an overarching strategy, equally there is a strong consensus regarding the need for a multiplicity of approaches, particularly when considering reaching deeper or more widely into the pool of potential post-16 scientists. A growing body of academic research does exist regarding student choice and how that choice differs between groups on the basis of gender, motivation, self-appraisal, family background, outside influences and school experience. However, it can be difficult to know how best to respond practically to the outcomes of research, given the variety of methodologies used and approaches taken.

Many schools are inspired by the challenge of raising their students' expectations and have shown that this is possible through studying science. Their successful strategies include: establishing a visible, positive school ethos regarding science; the development of strong, supportive leadership among senior staff; a culture of high expectation and maximum reward for students who succeed and progress; a willingness to challenge students at all levels; an active, integrated science team combining subject specialism and pastoral care; a diversity of qualification choice and teaching methods enabling students to be matched to courses; prominence of practical work within the curriculum, high-quality accommodation and equipment; time spent on staff–student and staff–parent relationships; assessment aimed at building confidence and understanding; responding to an individual's aspirations and feelings when interpreting the 'relevance' of science (not assuming that what is topical or newsworthy is necessarily relevant); and the availability and accessibility of enrichment activities for students and teacher support.

While it is widely acknowledged that it is not only the high-achievers in schools who may enjoy and succeed with post-16 science (indeed many of the high-achievers take science A-levels purely to move into medicine), it neither appears to be standard practice to promote the subject to those who may be relatively less able, nor to adapt the teaching to such people's needs. If the future success of science post-16 lies largely in the hands of teachers, the way in which they understand and engage with their role in relation to satisfying the needs of their students as well as national policy objectives will be crucial.

2 Actions

The following list of actions derives directly from the conference, but is grouped under categories for clarity. The conference recognized the government's positive disposition towards science, and a strong feeling was evident that government and the science and science education communities should work together to help increase post-16 uptake of science.

2.1 Specific actions for the government and its agencies

Overarching actions and important considerations

- Create and communicate an explicit, unifying strategy for post-16 science education that sets clear objectives and dictates policy decisions.
- Embed, with consensus gained through appropriate consultation, support across all the many strands of educational initiatives and reforms, to ensure that this unifying strategy is implemented successfully.
- Commit to reform only where it is clearly sustainable long-term and compatible with other reforms.

Key strategic priorities for action

- Recruit and retain sufficient numbers of specialist science and mathematics teachers.
- Correct the under-representation of certain ethnic minorities and young women, especially in the physical sciences.
- Ensure a better-integrated development and provision of mathematics and science in schools and colleges.
- Professionalize the careers advisory service.
- Develop a qualifications framework that serves the needs and interests of the widest range of students but is realistically deliverable within the current system.
- Improve school infrastructure for science.
- Redress the imbalance between academic and vocational courses.
- Promote assessment for learning.

Specific actions

- Publish comprehensive data on the uptake of science AS-levels to increase understanding of conversion between Key Stage 4 science and A-levels, and invest resource in the pre-16/post-16 transition to match that invested in the Key Stage 2/3 transition.
- Publish data, disaggregated by specialism, on initial teacher training targets in science and identify and release additional funding and expertise if targets with respect to science teacher supply continue to be missed.
- Consider appointing a Chief Adviser for Science Education.
- Improve significantly the quality and delivery of advice and guidance young people receive in relation to options and careers that require or benefit from a training in science, and show how reforms of the careers service will deliver improvements, how the training of careers advisers will include gaining experience of science, and how science teachers can increase their own understanding of science careers and how to promote them.
- Increase the range and effectiveness of incentives and rewards for non-specialist science teachers to become specialists, for example the accreditation of continuing professional development (CPD) in other subjects, possibly through Chartered Science Teacher Status.
- Reduce maximum class sizes in secondary school (for example from 30 to 24, though it is notable that in Scotland maximum class sizes average 20), which would help teachers particularly in practical classes where discipline is paramount.
- Monitor the interrelationships between schools and universities in regional clusters, particularly; the effects of the introduction of top-up fees on student choice of degree/university and therefore choice of post-16 study; and the impact on universities in areas where schools are unable to recruit sufficient qualified teachers and in areas where there is no regional provision.
- Require national initiatives such as the specialist schools programme to monitor impact on the uptake of science A-levels as part of their reporting process.
- Actively promote practical work that avoids the current pitfalls of standard GCSE coursework and encourages genuine investigation and illumination of concepts in all curriculum development.
- Consider the potential, negative impact of reducing the number of assessment units at A-level, as recommended by Tomlinson, on the provision of practical work – a key influence on student choice and a major skill needed for higher education.

2.2 Specific action for the science and science education communities

- The Royal Society, in partnership with the other learned societies and possibly Research Councils UK, Wellcome Trust and all universities, should seek to influence policy-making at the highest level.
- Reach consensus on the balance between subject knowledge and pedagogical skills that a science teacher needs to be equipped with in order to feel confident and secure in their teaching, and enjoy teaching, and ensure that professional standards in the teaching profession reflect how well teachers gain that balance.
- Seek and support better relationships with the education community to 'market' science in the best ways – through role models in the classroom, the media – and give greater and more visible recognition to, and celebration of, school success in promoting science.

- Widen and deepen industry–education links beyond existing funding arrangements, both to provide additional support to science education, improved careers advice in schools and to contribute to policy-making initiatives.
- Improve the fitness for purpose of science teaching and learning resources, particularly with respect to how well they present a modern image of science and scientists.
- Schools: should assess their own success culture and ethos in relation to science; the involvement of their science staff in wider school activities which give them greater status among the student body; and their internal marketing of subjects, particularly how their staff interact over this process.
- Share the experiences and good practices of science teachers in schools that are successful in promoting uptake of A-levels in their subject with the whole range of science teachers.
- Undertake more work with schools that are successful in generating interest in science A-levels to disseminate their strategies and good practice.
- Identify more precisely the skills and types of personnel needed by science and engineering employers so that an array of courses may be developed that provide young people with both a sound knowledge base and the potential to give young people access to the best opportunities for employment, and industry the best pool of talent.

3 Research recommendations

The conference demonstrated a need for the interdependency of research, reform and practice to be recognized. There is a requirement for a stronger research agenda and associated funding programme that coordinates support for a relevant, high quality, sustainable evidence base to inform policy and practice and reverse the declining popularity of the sciences post-16.

The research recommendations included below relate to gaps in knowledge highlighted at the conference and are set out under broad thematic headings. These gaps need to be filled in order to inform actions geared to increasing uptake of science post-16.

3.1 Impacts of change and reform

- Research the impact of a decreasing post-16 age group on choice of A-level science subject combinations, currently the most common route into science and engineering at tertiary level.
- Research the effect of sixth-form size on subject choices at A-level to test the hypothesis that smaller sixth forms produce proportionately fewer science candidates at A-level.
- Evaluate the extent of the threat posed to subjects like science that require a significant period of knowledge progression, by new subjects that can seemingly be studied without any previous knowledge at A-level and university.
- Examine the extent to which the widely supported aim of improving the quality of teaching and learning in school science education is associated with the aim of increasing the uptake of post-16 science – for government, educationists, teachers and others in the science education community – supported by research that shows where causal links can be made between quality improvement and post-16 uptake.
- Clarify the meaning of ‘relevance’ in relation to school science education and the perceptions of young people, and review whether unfounded assumptions are being made in the science education community regarding the meaning of relevance.

3.2 Progression and transition and the impact of the curriculum on these

- Investigate the effects of teaching the sciences in 11–16 and 11–18 schools, whether within a double- or triple-award curriculum at Key Stage 4, on progression to post-16 courses in the same and different institutions.
- Investigate and, where required, enhance the communication between and within clusters of feeder schools, sixth-form colleges and further education colleges to maximize opportunities for progression into science A-level.
- Investigate the transition from GCSE to A-level sciences among students who are less strong in these subjects and those who are 'late developers' to see if this may be improved.
- Identify the sources of inequity in school science provision and develop a more coherent, respected package of support for teaching approaches capable of meeting the variety of needs when seeking to increase uptake of science post-16, but particularly regarding young women and physics.

3.3 Choice and decision-making by young people, teachers and schools

- Conduct longitudinal studies that seek to increase our understanding of decision points at 16, 17 and 18, and an integration of that research with school-based knowledge and practice.
- Research students' perception of the relative difficulty of the sciences at A-level and how to tackle these perceptions.
- Investigate the factors affecting schools' and colleges' choice of which science qualifications at GCSE and post-16 to offer, and how/why they choose to encourage or discourage students from taking them.
- Conduct a thorough investigation into the ways in which science is organized and supported in schools that are particularly effective in promoting post-16 take-up.
- Investigate the impact of allowing schools to choose whether or not to provide post-16 education on the already uneven distribution of subject specialist teachers, and adjust policy if necessary.
- Carry out a systematic study of the current reforms at Key Stage 4 and post-16 on take-up of science post-16, and include impacts on progression to post-16 as a critical factor when reviewing, regulating and developing the science curriculum and qualifications, for example in relation to new, applied routes, the trialling of new qualifications and the review of the Key Stage 3 curriculum.
- Identification and promotion of the learning value of science for students who will not study any science post-16.

3.4 Comparative analyses

- Compare differences across the school and college sectors regarding key indicators in post-16 science uptake, including: GCSE provision and student attainment; subject combinations at A-level; availability of subject specialists in teaching staff; and success in progressing students to research-oriented universities.
- Compare the English and Scottish systems of pre- and post-16 curricula and qualifications in the sciences.
- Conduct a thorough exploration of comparative retention rates and popularity within and between the sciences and other subjects.

Introduction

This report is based on an all-day conference organized by and held at the Royal Society on 10 March 2006, attended by around 80 invited participants (see Appendix 1 for a full list; Appendix 2 contains the conference programme).

The conference aimed to inject fresh impetus into the longstanding debate over how to effect an increase in science uptake post-16, and to find new ways to help reverse the decline in the uptake of A-levels in the physical sciences and mathematics.[1]

Specifically, it sought to generate new recommendations for research and other action through evidence-based review of:

- trends in the uptake of science and mathematics A-levels;
- the impact or likely impact on uptake of recent/current educational reforms; and
- examples of good practice in schools that have particularly good track records in achieving progression to and performance in A-level science.

The conference consisted in the main of presentations by key researchers and practitioners in science education, interspersed by question and answer sessions and open discussion. For the final session participants were divided into breakout groups to discuss the evidence presented in the context of key questions and make recommendations for a research agenda or other action.

1 Throughout this report the terms 'science' and 'the sciences' are normally taken to include biological sciences, chemistry, physics and mathematics, unless stated otherwise.

The detailed papers, presentations and handouts provided at the conference may be accessed at **www.royalsoc.ac.uk/education/14-19Education**

Participants were welcomed to the conference by Professor Patrick Dowling CBE FREng FRS, Chair of the Royal Society's Education Committee, who outlined the challenges currently facing the science education community and the Society, and set out the objectives of the conference. Professor Dowling noted that the past three years have seen a stream of major government initiatives – reviews, enquiries and White Papers – relating to the 14–19 curriculum, the future of higher education, and the introduction of its ten-year framework for investment in science and innovation. All have left the science education community facing an unprecedented pace and volume of change.

At the same time the community is battling a continuing and significant decline since 1991 in the numbers of students taking A-levels in physics, chemistry and mathematics, despite an increase in the overall number of A-level entries in this period. The government's ten-year framework is intended to address these issues, but lacks a clearly defined strategy and measurable targets.

This conference, part of the Royal Society's strategy to shape the UK's science education, sought to unite the science education community around a way forward, by examining evidence with a view to gaining a clearer sense of what is realistically achievable; sharing views and generating recommendations for further action and research; and making real progress on the ambition of increasing the numbers choosing science post-16.

Note: the views expressed in this report are not necessarily those of the Royal Society.

Statistical trends in post-16 uptake of science

From pupil to scientist – more or less? Findings and indications from the available data

Professor John Howson and Dr Almut Sprigade, Education Data Surveys Ltd

This presentation was supported by a background paper and associated handouts, examining in detail the issues and data covered.

The presentation focused on a number of key issues, including:

- the decline in the number of 16–18 year olds;
- the importance of double-award science at GCSE;
- key decision points at 16 and 18;
- the growth in choice of subjects;
- AS-levels – a threat or an opportunity?
- the market place and growth of subject choice;
- the university destinations of students from different types of schools and colleges; and
- teacher supply.

1 Trends in student population and GCSE entries

1.1 The decline in the number of 16–18 year olds

Between 1992 and 2005 the number of pupils in secondary schools rose from 2.8 million to 3.3 million, but over the next decade the secondary school population will be in long-term decline as a result of a fall in the birth rate. This will lead eventually to a corresponding fall in the number of 18 year olds likely to go on to higher education.

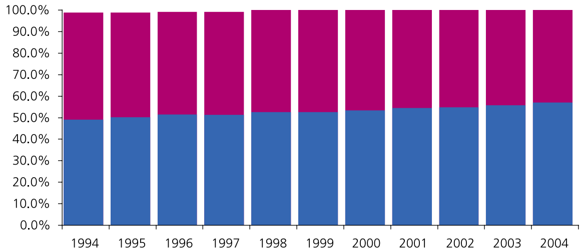
1.2 The importance of double-award science at GCSE

1.2.1 Entries

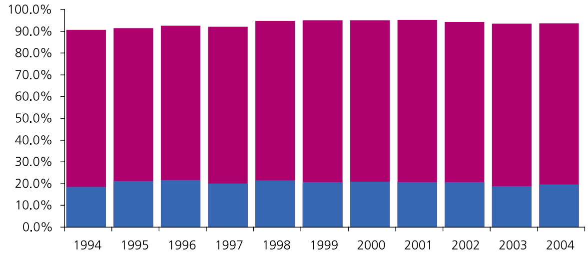
The majority of those who studied science during the past decade have been entered for the double-award science GCSE, with a rise in entries of around a quarter (from 380,893 in 1994 to 479,591 in 2004). The rate of increase in entries in the separate sciences was lower over the same period, at 17% for biological sciences (up from 37,129 to 44,758), 17% for chemistry (up from 35,764 to 43,073) and 16.7% (up from 35,394 to 42,501) for physics. For the single science award, entries actually dropped by around 9% (from 60,488 to 54,994).

Figure 1. Performance in selected GCSE science subjects over time (1999–2004).

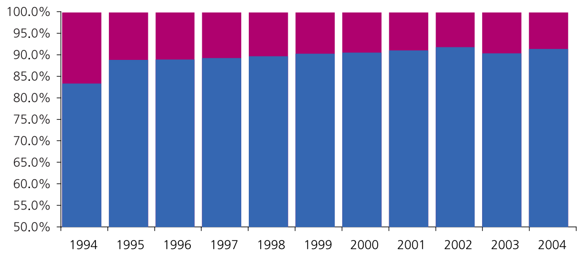
GCSE Double-award science



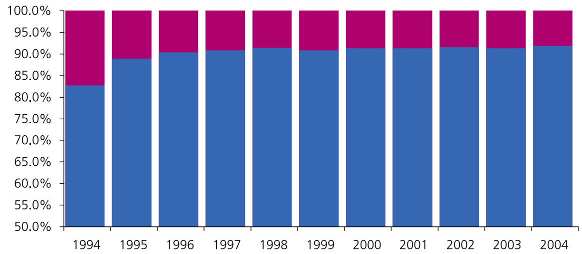
GCSE Single-award science



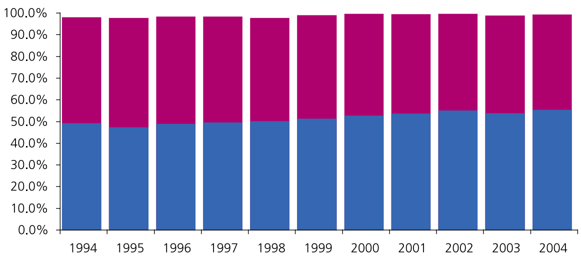
GCSE Biological Sciences



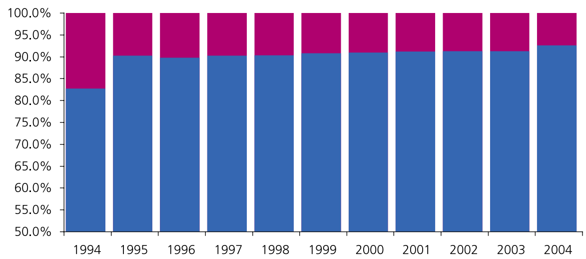
GCSE Chemistry



GCSE Mathematics



GCSE Physics



A*–G A*–C

(Source: DfES, 2005)

1.2.2 Grades

During the same period, the percentage of candidates achieving A*–C grades in double-award science increased (from 46.3% in 1994 to 54.2% in 2004), as did that for the separate sciences over the same period (biological sciences, from 82% to 90.1%; physics, from 81.3% to 91.2%; chemistry, from 81.3% to 90.4%). However, in single-award science, between 1994 and 2004, the numbers of candidates gaining A*–C grades rose only by 1%, from 15.8% to 16.8% (figure 1).

1.2.3 Conclusion

Taken as a whole, these figures appear to indicate that weaker students tend to take single-award science, and that their number is comparatively small. They also confirm the predominance of double-award science at GCSE, but show that higher proportions of A*–C grades are consistently attained by candidates taking the separate sciences.

2 Post-16 decisions and trends

2.1 Key decision points at 16 and 18

Prior to ages 16 and 18, students have to make crucial decisions regarding subject choice and career direction. The two key factors affecting their decisions over the past few years have been (i) the introduction of the intermediate AS and A2 qualifications in 2001, offering a possible exit qualification after one year of study; and (ii) a significant broadening of the range of subjects on offer in the post-16 curriculum and at degree level.

Despite a rise of around 14% in the total A-level cohort between 2001 and 2005,[1] during this period entries in chemistry and physics fell, respectively, by about 700 (down 2.1%) and 4000 (down 14%), and there was a similar decline in mathematics (down 8120, or 15%). Entries, in the biological sciences, however, rose by over 1100 (up 2.4%).

This pattern of subject entry is largely defined by maintained schools, which field by far the largest numbers of candidates. The declines in entries in chemistry and especially physics in the maintained sector were reflected in the independent (and next largest) sector, but while biological sciences entries rose in the former, they stayed flat in the latter. Amongst the sixth form colleges, there were small rises in entries in biological sciences and chemistry, but a significant drop in physics. Entries from the wider further education (FE) sector declined in all science subjects, the sharpest drop (29%) being in physics (albeit from a low base).[2]

There are many possible reasons why students choose not to study science subjects and mathematics to A-level, including their perceived difficulty, and the introduction of AS-levels (see § 2.2). There is evidence to suggest that schools and colleges, whether by accident or design (with marginal candidates being persuaded not to continue in a subject for the sake of a school's league table position), are ensuring that students who take A-levels are sufficiently prepared to be able to pass them.

2.2 AS-levels: a threat or an opportunity?

AS-levels represent a potential opportunity for students to continue science studies for a further year after completing their GCSEs, and thereby study more science post-16 than would otherwise be the case. Further, their AS-level experience may help encourage them to take the full A-level. However, because AS-levels are decoupled from A-levels, students may equally choose to drop subjects and so not complete A-level courses.

Reliable data on the uptake of science AS-levels are lacking. The Third Report of the Science and Technology Committee's report on science education 14–19 stated: '… it is not possible to draw any firm conclusions because the statistics do not show a true picture of the number of students studying AS-levels'.[3] Although this report was published in 2002, only a year after the introduction of the new Advanced Subsidiary levels, data have been under-counted since then (DfES, personal communication, January 2006). Nonetheless, data on progression from AS-level to A-level reported in a study by the Qualifications and Curriculum Authority (QCA) suggest relatively low conversion rates for both mathematics and physics and that, with the exception of mathematics, these have generally been falling since the new Advanced Subsidiary courses were introduced in 2001 (table 1).[4]

Table 1. A-level as a proportion (%) of AS-level (all subjects)

Subject	2001	2002	2003	2004
Mathematics	82.6	62.1	64.1	66.0
English	92.4	74.1	72.6	72.5
Physics	88.2	69.6	67.3	65.2
Geography	92.8	72.4	72.2	72.3
Further Mathematics	68.4	68.9	70.4	68.4

(Source: QCA, 2006, p. 22)

1 DfES SFR26_2005.

2 *Ibid.*

3 House of Commons Science and Technology Committee 2002 *Science education from 14 to 19*. Third Report, paragraph 47.

4 QCA 2006 *Evaluation of participation in A level mathematics – interim report*, p. 22. London: Qualifications and Curriculum Authority.

Table 2. Most common A-level combinations of science and mathematics subjects of at least three subjects in 2001–2003 (%)[5]

Subject	2001	2002	2003
Biology, Chemistry, Mathematics	100	60.35	62.0
Chemistry, Physics, Mathematics	100	61.7	55.7
Physics, Mathematics, Computing	100	74.1	66.4
Chemistry, Physics, Mathematics, Further Mathematics	100	69.6	61.6
Biology, Chemistry, Physics, Mathematics	100	105.9	93.4

(Source: QCA, 2006, p. 29)

Table 3. Acceptances to selected science subjects by school type (2002–2005)

Subject line (JACS)*	Year	Maintained Schools	Independent	FE Sector Colleges	Sixth Form Colleges	Other	Not known	Total
Biological Sciences (C1)	2002	2,211	633	692	551	45	827	4,959
	2003	2,177	652	661	506	50	747	4,793
	2004	2,015	626	611	550	54	785	4,641
	2005	2,204	631	622	564	66	848	4,935
Chemistry (F1)	2002	1,510	403	356	393	40	401	3,103
	2003	1,473	417	341	376	50	435	3,092
	2004	1,501	439	355	409	40	345	3,089
	2005	1,709	494	379	463	52	389	3,486
Computer Sciences (G4)	2002	4,937	825	4,837	1,736	238	4,471	17,044
	2003	4,433	608	4,762	1,584	218	3,886	15,491
	2004	3,634	522	4,152	1,331	252	3,395	13,286
	2005	3,666	473	3,602	1,115	243	3,770	12,869
Mathematics (G1)	2002	1,812	578	343	502	40	565	3,840
	2003	2,017	693	442	676	54	484	4,366
	2004	2,283	701	473	711	55	555	4,778
	2005	2,594	779	517	690	53	630	5,263
Physics (F3)	2002	1,593	370	281	320	32	312	2,908
	2003	1,565	414	255	326	36	309	2,905
	2004	1,428	388	225	288	34	308	2,671
	2005	1,549	368	244	307	39	420	2,927

(Source: UCAS customized dataset)

* Please note that the subject lines refer to subject lines not to the larger subject groups.

5 The figures for 2002 and 2003 are the proportions of change in percentage terms from the 2001 numbers.

Table 4. Applications and acceptances to computer science courses between 2001 and 2005

	2001	2002	2003	2004	2005
Applications	121,758	91,418	78,304	62,593	61,491
Acceptances	22,842	17,044	15,491	13,286	12,869

(Source: UCAS)

2.3 The market place and growth in subject choice

The decline in physics entries between 2001 and 2005 (see § 2.1), which mirrors the position in mathematics and comes at a time when the total number of A-level entries rose by some 65,600, is the most worrying.[6] This drop in market share is due partly to the increased range of combinations on offer and to the option of dropping subjects after AS-level (see § 2.2).

Owing to the large number of different combinations of subjects available to post-16 students and the opportunity to start more subjects than are needed for university entrance, each subject (science or otherwise) commands a smaller potential and actual proportion of the total market share. The same is true of the traditional subject combinations; the aforementioned QCA report suggests that apart from the biology, physics, chemistry and mathematics combination, other historically popular combinations of A-levels (eg biology, chemistry and mathematics) have been losing ground to newer subject combinations (mostly not including science) or to students dropping one or more subjects having completed the AS-level (table 2). Notably, while the independent sector is considerably smaller than the maintained sector, the QCA report indicates that it was overrepresented amongst the entries from candidates taking most of the three science combinations and those taking two sciences plus mathematics.

3 From A-level to university

3.1 Trends in entries to higher education courses in the sciences

Higher education has seen the same sort of expansion in recent years as the schools sector; this is due partly to increased numbers in the cohort and partly to an increased take-up of higher education places. Even the sciences have benefited from this increase in numbers, with small rises in some science courses, including physics, chemistry and mathematics, whilst biological sciences have remained relatively stable. All these subject groups recorded a rise between 2004 and 2005 (table 3). However, since 2002 there has been a sharp decline in the numbers accepted to computer science courses, mirroring the decline of the dot.com industry (table 4)[7].

3.2 The university destinations of students from different types of schools and colleges

For the purposes of a study into UCAS data from 2002 to 2005, institutions in the higher education sector were placed into one of three groups: the ‘Russell Group’ universities (19 pre-1992 universities and colleges with a focus on research), other pre-1992 universities, and post-1992 universities and colleges. The study showed that students from independent schools are most likely to progress to Russell Group universities (table 5). For instance, in mathematics in 2005, 74% of students from independent schools were at Russell Group universities. For the other three types of institutions preparing A-level candidates, the percentages at Russell Group universities ranged from 47% to 55%.
In physics, chemistry and biological sciences, between 58% and 75% of independent school pupils went to Russell Group universities, compared with between 22% and 66% of students from other institutions.[8] The FE sector generally had the lowest percentages of students progressing to Russell Group universities, but the sixth form colleges were comparatively successful in progressing students to research-oriented universities.

6 QCA 2006 *Evaluation of participation in A level mathematics* – interim report. Appendix A, table 2, p. 5. London: Qualifications and Curriculum Authority.

7 Note that due to the introduction of the Joint Academic Coding System (JACS) in 2002, 2002 data in table 4 may not be directly comparable to previous years’ data.

8 UCAS customized dataset 1. Applications and acceptances to selected sciences courses, 2002–2005, by school type and type of institution.

Table 5. Acceptances to selected science courses by type of school and institution (2002–2005)

Subject line (JACS)	Year	Institution types	Independent	Maintained Schools	FE Sector Colleges	Sixth Form Colleges
Biological Sciences (C1)	2002	Post-'92 and other institutions	5.8%	20.9%	47.0%	22.0%
		Pre-'92 institutions	28.4%	39.4%	31.4%	35.9%
		Russell Group	65.7%	39.7%	21.7%	42.1%
	2003	Post-'92 and other institutions	8.9%	22.5%	46.6%	25.1%
		Pre-'92 institutions	29.6%	37.9%	31.6%	36.4%
		Russell Group	61.5%	39.5%	21.8%	38.5%
	2004	Post-'92 and other institutions	9.6%	22.6%	41.9%	20.0%
		Pre-'92 institutions	27.8%	39.1%	35.8%	35.3%
		Russell Group	62.6%	38.3%	22.3%	44.7%
	2005	Post-'92 and other institutions	7.6%	23.6%	42.8%	24.1%
		Pre-'92 institutions	34.4%	39.1%	33.9%	34.4%
		Russell Group	58.0%	37.3%	23.3%	41.5%
Chemistry (F1)	2002	Post-'92 and other institutions	4.7%	12.0%	38.2%	23.2%
		Pre-'92 institutions	20.8%	40.5%	29.8%	23.2%
		Russell Group	74.4%	47.5%	32.0%	53.7%
	2003	Post-'92 and other institutions	5.3%	12.2%	32.3%	21.5%
		Pre-'92 institutions	22.8%	40.0%	35.8%	29.0%
		Russell Group	71.9%	47.9%	32.0%	49.5%
	2004	Post-'92 and other institutions	5.9%	12.8%	28.7%	21.0%
		Pre-'92 institutions	26.0%	40.5%	32.4%	29.6%
		Russell Group	68.1%	46.7%	38.9%	49.4%
	2005	Post-'92 and other institutions	4.0%	10.0%	29.0%	13.8%
		Pre-'92 institutions	24.7%	39.8%	36.1%	32.2%
		Russell Group	71.3%	50.1%	34.8%	54.0%

Table 5 continued overleaf

Table 5. Acceptances to selected science courses by type of school and institution (2002–2005)

Subject line (JACS)	Year	Institution types	Independent	Maintained Schools	FE Sector Colleges	Sixth Form Colleges
Computer Sciences (G4)	2002	Post-'92 and other institutions	22.9%	51.9%	80.6%	57.9%
		Pre-'92 institutions	32.8%	30.2%	14.6%	25.0%
		Russell Group	44.2%	17.9%	4.8%	17.1%
	2003	Post-'92 and other institutions	21.9%	56.4%	81.5%	57.6%
		Pre-'92 institutions	32.7%	28.5%	13.8%	27.7%
		Russell Group	45.4%	15.1%	4.7%	14.8%
	2004	Post-'92 and other institutions	23.0%	57.2%	81.3%	57.6%
		Pre-'92 institutions	31.8%	28.0%	14.2%	25.7%
		Russell Group	45.2%	14.7%	4.5%	16.8%
	2005	Post-'92 and other institutions	24.9%	57.3%	81.4%	58.9%
		Pre-'92 institutions	36.8%	28.8%	14.6%	28.4%
		Russell Group	38.3%	13.9%	4.0%	12.6%
Mathematics (G1)	2002	Post-'92 and other institutions	1.0%	4.1%	14.9%	9.4%
		Pre-'92 institutions	22.5%	39.5%	39.9%	32.5%
		Russell Group	76.5%	56.3%	45.2%	58.2%
	2003	Post-'92 and other institutions	2.0%	6.6%	15.6%	8.4%
		Pre-'92 institutions	22.2%	39.3%	36.0%	30.8%
		Russell Group	75.8%	54.1%	48.4%	60.8%
	2004	Post-'92 and other institutions	2.6%	7.6%	17.8%	9.0%
		Pre-'92 institutions	24.8%	39.8%	36.4%	34.3%
		Russell Group	72.6%	52.6%	45.9%	56.7%
	2005	Post-'92 and other institutions	1.0%	8.4%	17.4%	12.2%
		Pre-'92 institutions	25.0%	40.2%	35.4%	33.0%
		Russell Group	73.9%	51.3%	47.2%	54.8%

Table 5. (Continued.)

Subject line (JACS)	Year	Institution types	Independent	Maintained Schools	FE Sector Colleges	Sixth Form Colleges
Physics (F3)	2002	Post-'92 and other institutions	0.8%	3.2%	8.5%	2.5%
		Pre-'92 institutions	24.6%	39.9%	41.6%	33.4%
		Russell Group	74.6%	56.9%	49.8%	64.1%
	2003	Post-'92 and other institutions	1.4%	2.7%	6.7%	3.7%
		Pre-'92 institutions	28.0%	38.7%	51.4%	32.5%
		Russell Group	70.5%	58.7%	42.0%	63.8%
	2004	Post-'92 and other institutions	0.0%	2.0%	5.8%	1.4%
		Pre-'92 institutions	26.0%	40.3%	43.6%	32.3%
		Russell Group	74.0%	57.7%	50.7%	66.3%
	2005	Post-'92 and other institutions	0.0%	1.5%	2.5%	1.3%
		Pre-'92 institutions	29.1%	39.6%	48.4%	37.8%
		Russell Group	70.9%	58.8%	49.2%	60.9%

(Source: UCAS customized dataset)

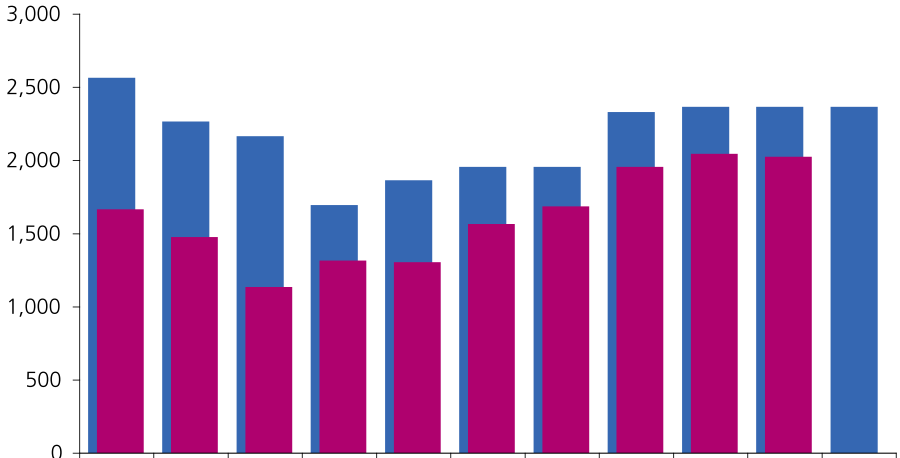
In order to investigate the transfer from school to university from another perspective, higher education institutions were grouped into five bands according to their overall research income, ranging from £10m to over £50m. Similar patterns emerged, with universities with large research incomes taking the bulk of the students; for example, in chemistry and physics in 2005, institutions with less than £10m of research income took under a quarter the number of students taken by institutions with more than £50m research income.[9]

9 UCAS customized dataset 2: Applications and acceptances to selected science courses, 2002–2005, by school type and research income of institution (based on HESA research income information).

4 Teacher supply

The uptake of science and mathematics post-16 will depend to a great extent upon the availability of sufficient numbers of well-qualified teachers. The supply of teachers becomes even more vital in a period when freedom over the choice of school for parents and students is government policy. The option to allow schools to choose whether or not to provide post-16 education might also have an effect on the distribution of teachers, if there are insufficient numbers for all schools.

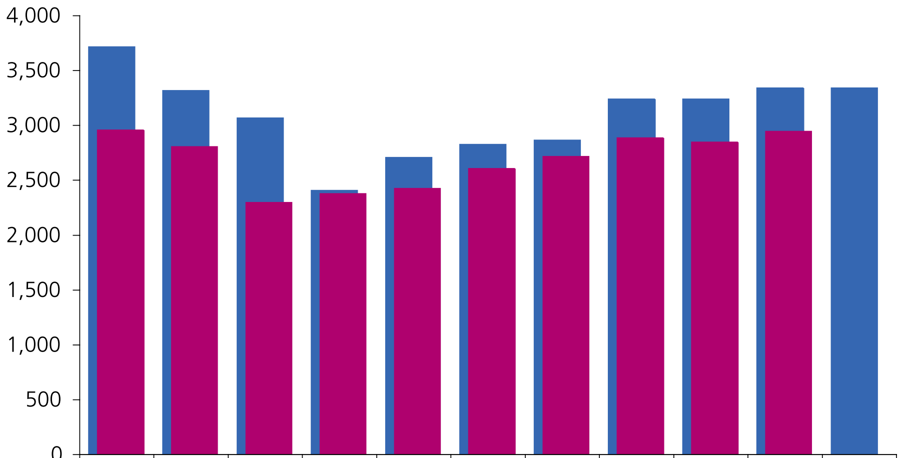
Figure 2. Initial Teacher Training, Mathematics



	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Target	2,550	2,250	2,150	1,680	1,850	1,940	1,940	2,315	2,350	2,350	2,350
Intake	1,650	1,460	1,120	1,300	1,290	1,550	1,670	1,940	2,030	2,010	

(Source: DfES time-series)

Figure 3. Initial Teacher Training, Sciences



	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Target	3,700	3,300	3,050	2,390	2,690	2,810	2,850	3,225	3,225	3,325	3,325
Intake	2,940	2,790	2,280	2,360	2,410	2,590	2,700	2,870	2,830	2,930	

(Source: DfES time-series)

The government has failed to meet its initial teacher training (ITT) targets for mathematics in the last decade, and the position in the sciences is similar, with the added complication that no formal account is taken of the type of science studied by trainee teachers during their degree courses (figures 2 and 3). Consequently there are no accurate trend data about the numbers of teachers with different science specialisms, and their deployment, although a recent study by the National Foundation for Educational Research (NFER) indicated that most specialist science teachers are biology specialists (44%) and that there is great inequity in the way that science teachers are distributed between schools.[10] With an average of between 33% and 40% of teachers in secondary schools likely to retire over the next ten years, any shortfall in training against the targets will mean that schools could face a deficit. This will need to be overcome by either professional development or recruiting trained teachers from other sources.

5 Key messages

- The dramatic increase in the combination of subjects available to students both at 16 and at university offers the science education community the possibility of students studying one or more sciences when they might previously have not studied any. However, the greater risk is that they will abandon sciences for other newer subjects. Any trend away from sciences might be affected by perceptions of whether the alternatives are either as enjoyable or as difficult as the sciences or mathematics. The 'lure of the new' might outweigh the 'fear of the unknown'
- The growth in subject combinations occurred during a period when the school population was increasing as a result of an increase both in staying-on rates and in the total number of 15–19 year olds. As the post-16 age group reduces in size over the forthcoming decade, there may be some reduction in the range of subject combinations that are sustainable: the key must be to ensure that it is not the sciences that disappear.
- It appears that AS-levels pose both a threat to the take-up of A-level entries and an opportunity for more students to study science subjects post-16, although insufficient data are available at present to fully determine the trend.
- The current proposal to allow more schools to create sixth forms at a time when overall rolls are falling also has potential implications for the sciences. More work might usefully be undertaken on the effect of sixth-form size on subject choices at A-level in order to test the hypothesis that smaller sixth forms produce proportionally fewer science candidates at A-level.
- The outcomes at the two key choice points at 16 and 18 are crucial in determining the numbers selecting sciences and mathematics at the next stage. A key issue for the future is how to attract the students who are less strong in these subjects, and those who are late developers or 'late learners' who are interested in science but have underachieved up to GCSE, perhaps as a result of poor motivation or fragmented and possibly uninspiring teaching. Managing the transition from GCSE to post-16 study is of vital importance.
- There are unanswered questions about how the higher education market will operate in the environment of top-up fees – whether students will be more reluctant to undertake four-year courses, or wish to study closer to home, or look for subjects where outcomes are more likely to be higher in terms of class of degree. It is to be expected that perceptions of job/career prospects and the competitiveness of salaries will influence their decision-making.
- The introduction of new subjects that can seemingly be studied without any previous knowledge, either at 16 or in higher education, poses a threat to subjects that make clear that they are building upon previous expected knowledge.
- Without sufficient teachers equipped to teach a subject, the whole basis of learning may be compromised. It would be if universities able to offer places in the sciences and mathematics were located in the very areas where schools were unable to recruit sufficient qualified teachers, and this issue merits further examination.
- If we want to produce more scientists we have to produce enough science teachers, and in a choice-driven labour market the job of teaching science has to be made sufficiently attractive, whether in terms of conditions and benefits or in terms of the teaching environment.

10 Moor, H, Jones, M, Johnson, F, Martin, K, Cowell, E & Bojke, C 2006 *Mathematics and science in secondary schools: the deployment of teachers and support staff to deliver the curriculum*. NFER Trading Ltd.

6 Questions and discussion

Q. What is known about progression rates from double science into A-level as compared to progression rates in single science subjects into A-level?

A. ***I am afraid for the purposes of this morning, I cannot say very much about that, as we have not looked at that particular aspect of it.*** But the whole implication about transition and how you manage it is important in terms of that equation I was talking about between the risk of the known and fear of the unknown. One argument is that there is a group of high achievers who will be destined to take the sciences at A-level, and there is another marginal group who may be persuaded to take the sciences by the utility and comfort factors: utility, because they see that they wish to progress into a particular career area that requires these subjects and they are prepared to take the risk if they feel confident in the learning environment they are in and be enabled to achieve the progression they desire. But if people do move around more, then will people who move from schools to sixth form colleges be more likely to drop out of science, or stay in science, given the unfamiliarity of the new institution and concerns that the teaching will be different?

Q. Is it not ultimately the government's responsibility to reverse the decline in science entries over the past 15 years? Should the Royal Society adopt a more emphatic approach in seeking to galvanize the government into action?

A. ***It would not be productive to simply hand the problem over to the government, but it is precisely because the Royal Society is frustrated at the lack of progress that it is putting extra resources into influencing policy.*** One of the purposes of this conference is to ensure that our advice to government will be well informed.

6.1 Other notable remarks of participants

- The Scottish system of combining science is rather different, equivalent to GCSE separate sciences. There is more progression into science post-16 in Scotland than in England, which might be a fruitful area for research. One possible factor is that in Scotland the science qualification is applications-led rather than theory-led and so more attractive to students.

- If the proposed cut in the number of modules at A-level, as recommended by Tomlinson, leads to a reduction in practical work, there is a danger that this would make A-level less attractive to students.

- GCSE science should not be seen primarily in terms of how likely it is to increase numbers post-16. We need to engage and retain students' interest in science; if they find it stimulating and motivating they will choose to continue to study it. Students are also responsive to market forces, and in a choice-driven environment they will choose the 'product' that appeals to them (though, perhaps, without adequate information).

The impact of educational reform on science uptake post-16

Educational reform and the take-up of science post-16

Professor Jim Donnelly and Professor Edgar Jenkins,
Centre for Studies in Science and Mathematics Education, University of Leeds

This presentation was supported by a background paper that examined in detail the issues covered. The presentation was in three parts: Professor Donnelly began with a review of current initiatives and circumstances and their possible outcomes; Professor Jenkins outlined the findings of research into influences on students' choice of subject post-16; and Professor Donnelly concluded with some suggestions for possible ways forward.

1 Current initiatives and circumstances

1.1 Curriculum/assessment reform

The largest single initiative currently facing school science education is the new system of GCSEs, to be taught from September 2006, emphasizing scientific literacy, a vocational/applied strand, and diversity in the range and combinations of courses available. It remains to be seen whether the reforms will influence post-16 take-up; they do not seem to have been designed with this purpose in mind, but have nonetheless been appropriated for this purpose by the government. Other innovations include the new A-level in applied science, which might offer a route to students who have taken the GCSE double-award applied science; the White Paper *14–19 Education and skills*; the RSA 'Opening Minds' project with its focus on competences; and innovative specifications for A-level physics and biology.

1.2 National strategies

The government has intervened more and more in classroom pedagogy. The primary and secondary national strategies were introduced ostensibly to develop teachers' professional practice individually and at departmental and whole-school levels; they assume that there is 'best' (rather than 'good') practice applicable to all teachers and students.

1.3 Management and governance of schools

The most prominent reform is the specialist school system, with over 300 designated specialist science colleges. It is not yet clear how these will impact on the take-up of science post-16.

1.4 Science teacher supply, training, deployment and development

The range of government interventions includes a short-lived National Curriculum for initial teacher training; financial support for trainees in all science subjects; a progressive system of 'standards' against which teachers can be evaluated at various stages of their careers and which is meant to support progression; and the national network of Science Learning Centres, with a particular focus on supporting and developing teachers' knowledge and professional competence. All these initiatives are designed to improve the quality of science teaching, which the government sees as key to increasing take-up of science post-16.

1.5 Other initiatives

Smaller-scale initiatives directed towards increasing students' interest in, and involvement with, science include the Researchers in Residence programme, the Science and Engineering Ambassadors scheme and the Royal Society's

Partnership Grants scheme. These are significant because they invariably involve bringing university/industry scientists and engineers into schools, which represents quite a challenge given the other agendas that these people have.

2 Possible impacts of current reforms on post-16 take-up

2.1 Curriculum reform

Statutory curriculum reform creates distortions and intellectual problems, especially when linked to high-stakes assessment, and its impact on gender balance and post-16 take-up of science has been very limited. However, flexibility and choice in curriculum options create different problems, as teachers may elect to remain in the 'comfort zone'. The new 'applied' route has potential, but it is too early as yet to comment on its possible impact: possibilities for progression are critical here.

2.2 The influence of teachers and schools

Teachers are the largest single source of variance in learning other than the students themselves. Currently only 20% of teachers in secondary schools are physics specialists, compared to 25% of chemists and 44% of biologists, and nearly a quarter of 11–16 schools have no teacher who has studied physics to any level at university. The situation is mediated by school deployment policies, and it is clear that the supply and deployment (particularly of physicists) within and across schools is very patchy, with those in challenging circumstances suffering.[1] The relationship of specialist knowledge to enthusiasm, confidence, flexibility and pupil attainment is well established. In 1998 Ofsted noted that:

'When teachers are thoroughly in command of their subject, they are able to adapt their teaching to the responses of the pupils, to use alternative and more imaginative ways of explaining, and to make connections between aspects of their subject and with pupils' wider experiences, so capturing their attention and interest. The teacher's ability to answer spontaneous questions is an important factor in generating enthusiasm for the subject.'[2]

Individual schools and departments can have a large impact on post-16 take-up, as evidenced by one particular school that was highlighted in the Annual Report for 2004/05 by HM Chief Inspector of Schools. But the mechanisms are multifaceted, and perhaps unpalatable for some (eg the encouragement of separate sciences and targeting students with an enthusiasm for science).

Students for their part have varying views about science, citing the attractions of laboratory work, of 'discussion', 'relevance' and controversy, and of independence; but also admitting to ambivalence in the face of the authority of science and of the teacher, which makes it more difficult (but not impossible) for pupils to display individuality and creativity.

3 Research into what influences students' choice of subjects post-16

A great deal of research has been done into why young people are less likely to study physics, chemistry and particularly mathematics after the age of 16.[3,4,5] The research reflects different perspectives and different methodologies, with some conflicting and some interesting results, including for example that the quality of teaching is not necessarily a significant factor for students who choose to continue with science in the sixth form. Research also shows that attitudes towards science decline as students progress through secondary schooling, and that attitudes towards physics, chemistry and biology are different.

Other studies have revealed that 90% of careers advisers do not have a scientific background, and that they have tended not to give students much advice about the careers opportunities that are available in science, because science is a compulsory subject at Key Stage 4. There is evidence that the careers service is more focused on students that are likely to drop out of education or training. There is also evidence of a lack of understanding of the kind of work that scientists do, and a stereotypical image of scientists as (mainly) men in white coats, which is at odds with teenagers' concerns over image and lifestyle – often more important for them at this stage of their lives than subject and career choice. A third strand of research relates to whether there is an identifiable 'scientific personality', but even if this exists it is unlikely to have a clear bearing on students' choices at 16.

1 Smithers, A & Robinson, P 2005 *Physics in schools and colleges: teacher deployment and student outcomes*. Buckingham: Carmichael Press.

2 Ofsted 1998 *Secondary education 1993–97: a review of secondary schools in England*. London: The Stationery Office.

3 Jones, M G, Howe, A, Rua, M J 2000 Gender differences in students' experiences, interests and attitudes towards science and scientists. *Science Education* **82**, 180–192.

4 Brickhouse, N W, Lowery, P & Schultz, K 2000 What kind of girl does science? The construction of school science identities. *J. Res. Sci. Teaching* **37**, 444–458.

5 Stark, R & Gray, D 1999 Gender preferences in learning science. *Int. J. Sci. Ed.* **21**, 633–643.

The findings of the Relevance of Science Education Project (ROSE), an international project based at the University of Oslo, send very clear, strong and positive messages as to what students think about science and their school science education. Both boys and girls see science and technology as important, but many students do not find GCSE-level science interesting. A majority do not see GCSE-level science as 'difficult'.

As to whether the difficulty of A-level is a problem, a study sponsored by Siemens into the factors influencing students in their decision to take a science subject or mathematics at A-level found the following:

- their performance at GCSE was 'very important' (60%);
- their enjoyment of the subject at GCSE was 'very important' (69.4%);
- the level of difficulty of getting high grades at A-level was 'very important' (16.1%) and 'important' (48.7%); and
- between 62% and 82%, according to region within the UK, agreed that it is more difficult to get an A grade in science subjects at A-level. (In Scotland and Northern Ireland, however, most students do not think it is more difficult to get an A grade.)

There is a complex set of interacting variables governing student choice, and a deeper level of understanding requires a detailed, longitudinal study. A 1996 National Foundation for Educational Research study found that the type of school and its level of academic achievement are particularly influential, but so are factors such as staff turnover and level of teacher qualifications.[6] In more recent studies Cleaves (2003, 2005) concluded that students' choices derive from 'interplay of self-perception with respect to science, occupational images of working scientists, relationships with 'significant adults' and perceptions of school science'.[7, 8, 9]

The ROSE project also found that the UK is not alone in experiencing a lack of interest in science among school students, and especially girls; this attitude is common among developed countries, while a greater proportion of both boys and girls in developing countries find school science interesting and like it better than most other subjects. It may be that at least part of the problem lies outside the control of schools, and that we will also have to look at the wider factors that are shaping young people's perceptions of their role in the world and what contribution they can make to it.

4 Some key questions and ways forward

4.1 Distinguishing aims

A key question concerns the degree to which it is possible, or desirable, to distinguish the aim of improving the quality of teaching and learning in school science education from the aim of increasing the take-up of science post-16. The answer is, perhaps, that the two aims are distinct, except that it might be anticipated that an overall improvement in the quality of teaching and learning in school science education below the age of 16 might lead to an increased take-up beyond this age.

6 SCAA 1996 *The take-up of advanced mathematics and science courses*. London: School Curriculum and Assessment Authority.

7 Cleaves, A 2003 *Forming post-compulsory subject choices in school: a longitudinal study of changes in secondary school students' ideas with particular reference to choices about science*. Unpublished PhD thesis, University of London.

8 Cleaves, A 2005 The formation of science choices in secondary school. *Int. J. Sci. Ed.* **27**, 471–486.

9 Jenkins, E 2006 The student voice and school science education. *Stud. Sci. Ed.* **42**, 49–88.

4.2 Why do we wish to increase the take-up of science post-16?

There are three possible, but not mutually exclusive, answers to this question, with corresponding possible responses in policy and practice:

(i) Because it contributes to the overall quality of students' education?

Possible responses

- Make science a 'statutory' requirement?
- Develop our understanding of the educational benefits, and how to achieve them, both in curricular and pedagogic terms.
- Develop and trial courses appropriate to a wider range of students.

(ii) Because a greater supply of personnel with scientific knowledge is needed?

- Identify the types of personnel needed, and the types of course which supply them (they may not be high-level professional or 'academic' scientists, but at technical or other levels).
- Provide courses in the separate sciences for the more able students.
- Provide and support technical and applied courses.
- Create a higher profile for physics and chemistry throughout secondary schooling, eg through better resourcing.
- Make students aware of the career value of scientific qualifications.

(iii) Because there is inequity in the current provision, which is turning away some groups (women, certain ethnic groups), and this needs to be rectified on grounds of equality of opportunity?

- Identify the sources of inequity.
- Modify curricular and teaching methods.
- Provide training for teachers in the sources of inequity and how to avoid them.

Certain strategies are common to all of these possible purposes, including:

- interactive, lively and diverse methods of teaching;
- sensitivity to the knowledge, needs and responses of the learner;
- sensitivity to gender and other equity issues; and
- increased use of formative assessment to promote learning and help develop students' sense of responsibility for their own progress.

A research agenda might include the following:

- decide why we are promoting science post-16;
- carry out longitudinal studies of the bases of students' decision-making;
- seek information about the ways in which science is organized and supported in schools that are particularly effective in promoting post-16 take-up; and
- conduct a systematic study of the impact on take-up of the courses promoted within the current reforms at Key Stage 4 and post-16.

5 Questions and discussion

Q. The ROSE data on students' interest in science in developing and developed countries seemed to give two contradictory messages. The developing countries had higher levels of interest in science and more developed countries lower levels of interest in science, and that pattern was repeated in relation to schools. On the other hand the graph showed less interest in all countries when students were asked about science in school as opposed to science intrinsically. Is that the case and, if so, is it an international phenomenon that people are disappointed at their experiences of science at school?

A. *Firstly, girls in all countries are less interested in science and in school science than boys; that is universal.* Secondly, in the developing world people are much more positive about science and technology and want to study it, whereas in the developed world that is not the case on the whole. Thirdly, school science is regarded as relatively uninteresting in the developed world and significantly more interesting, though not massively so, in the developing world.

Q. Does that suggest that schooling does not matter or that it does matter?

A. *It does matter, but there may be aspects of the modern, or postmodern, industrialized world that are not as supportive of science as we would like, for example, the greater importance attached to feelings and emotions at the expense of the abstraction of ideas from the natural world.*

Q. The importance in research studies of the relationship between the qualifications of science teachers and their students' results is over-exaggerated. There are many examples of teachers with very high qualifications who cannot teach their subject very well.

A. *One has to be very careful.* It seems to me that you are saying that you cannot teach physics particularly well after 14 or 16 if you do not have a physics degree, because we can all think of people who do that reasonably well. Equally, you cannot go to the other extreme and say that you do not need to know any physics in order to teach physics.

5.1 Other notable remarks of participants

- We need to strike a balance between the two extremes of saying that you cannot teach physics after 14 or 16 without a degree and that you do not need to know any physics in order to teach it. We need to go back to the quotation from the 1998 Ofsted report about teachers being confident and secure in what they are teaching so that they can open up ideas and deal with children's questions in a way that they could not do without that command of their subject.

- In China and Hong Kong the mass of people are motivated to study science and technology as a means to increase their social and financial standing. They see it as an obvious route to wealth, because scientists are in very desirable positions and very wealthy. These are not goals or options that are open to us in the West.

- There is evidence that in India there has been a decline in science. This may be because it has the highest unemployment rates amongst PhD and Bachelor science graduates in the world.

- The key to attracting students to study science is enjoyment, and if they are to enjoy science they have to be taught by teachers who enjoy teaching it. Teachers who are obliged to teach outside their speciality will enjoy it once they have been properly trained to do so, as shown by the experience of a large project in Sussex which is training biologists to teach physics. There is no resistance on their part; they are eager to be shown how to do it. Focus on enjoyment and the rest will fall into place.

Showcasing success in schools: learning from examples of good practice

www.royalsoc.ac.uk/education/14-19Education

Lessons by example: showcasing success in schools and what may be learnt from this

Bob Ponchaud, Independent Consultant, former HMI with responsibility for science

This session was chaired by Bob Ponchaud, who began with a presentation outlining some of the pitfalls and benefits of case studies. Case studies from three individual schools followed.

1 Case study methodology

Case study methodology was used to identify successful practice in schools regarding uptake of science post-16, with a view to celebrating this and distinguishing common, potentially transferable features and methodologies.

There were a number of factors to be considered in planning these case studies:

Identification

What is successful? To provide an answer to this required looking largely at numerical data, seeking to identify schools where a substantially higher than average proportion of students go on to study at least one science subject post-16. For all schools visited or showcased this figure was in excess of 45%.

Location

Where is success to be found? All three schools selected as case studies are located in the south of England, for convenience.

Characteristics

What makes the schools so effective? Consensus was reached surprisingly quickly with the teachers on what made them effective.

Transfer

What can be transferred? This is a more thorny issue, but it was hoped that the studies would highlight a set of circumstances or characteristics that could be transferred to other schools.

Each of the three case studies covered the following:

Context

(i) Background information about the school and what it is like.

(ii) Features of practice. What has worked in the school? The strength of a case study is that something that has worked in one school might well work in another school with similar circumstances.

(iii) Professional reflection. What seems to colleagues to be valuable, using their long experience as professional educators to reflect on their own practice? This is one of the most valuable sources of information.

(iv) Selection of significant features. Each school was asked to focus on two of the following strands identified as contributing in some measure to their success:

- relevance;
- accessibility;
- success culture;
- difficulty;
- specialist teaching;
- confidence; and
- practical work.

2 Mike Januszewski, Head of Science, The Thomas Hardye School, Dorchester

This presentation began with video footage of students discussing their very positive experiences of science at The Thomas Hardye School, and the reasons why they decided to continue studying it. These included good teachers, enjoyment of and interest in the subject, and good facilities. His presentation focused on the school's success culture and its emphasis on confidence and practical work.

The school is a large mixed comprehensive in Dorset, with small class sizes (average 24) with up to 85% of all students staying on in the sixth form. High expectations for both behaviour and work are passed on from the head teacher through the staff and on to the students. Several powerful mottos are used to help create a success culture: 'Tell them they're doing well and they will', 'Catch them doing well', and 'Can do will do. Can't do won't do'. There is a strong pastoral system, and the science team of 25, supported by five technicians, is all part of the academic tutorial team, which offers one-to-one tutorial support. All are subject specialists, teaching two science subjects; they enjoy their work and support each other in everything they are trying to achieve. There is an equal male/female balance and a good mix of age and experience.

Students are taught in sets based on academic success. Matching the course to the student is considered an important factor in the school gaining 83% A*–C passes in GCSE science from a truly comprehensive intake. Currently six different courses from two different awarding bodies are being taught. Students enjoy practical and investigation work, which is at the core of all courses, and are continually challenged by their teachers, working to high expectations. Schemes of work, introduced about ten years ago, ensure continuity and equality of provision across a cohort of over 500 students. Science clubs are held after school for interest, revision and coursework, and masterclasses for AS and A2 courses are run by examiners from the awarding body.

The staff work hard and continuously to challenge some hard-held beliefs. They have adopted a hard line on entry policy with all their students, insisting for example on a grade B in order to be entered for the higher tier. They have adopted the same pragmatic attitude to how and what they teach, with the starting point that their job is to enable all students to gain a good GCSE in science.

They continuously monitor and feed back results to the students and try to lead them into more difficult work when they are ready. Assessment is used to gauge progress and improve performance; all work is marked and students are told what to do to improve and how to do it. In addition the school is developing Active Assessment for Learning Strategies. How the students are assessed is vitally important, as when it is wrong – for example if a student cannot understand what they are meant to do in an exam paper or question – it can destroy a student's confidence, especially in the early stages.

Large numbers opt for science in the sixth form because they have had a positive experience in the lower school. Another important factor is that the school has exceptionally strong mathematics and English departments, as science flourishes when students are successful in both those subjects. However, the school has found that with more students achieving grade C (as opposed to grades B, A or A*) at GCSE and wanting to continue with science, there is no properly suitable course to offer them.

The school is especially keen to foster students who are not from a scientific background, and has found that where a student's parents were 'no good at science' at school they are eager to encourage their child to continue with it if they can see that they are doing well. The school maintains a good 'communication triangle' between school, student and parents; it keeps parents informed about test results and coursework, and receives good support in return.

The school makes a point of stressing the employability that science qualifications bring – not only in terms of careers in science but also the transferability to other jobs of the sorts of skills that employers are seeking.

The funding that has come with the science department's success has greatly increased its status in the school and given it superb resources. It is running a wide range of courses at all levels, and is hoping to enter 50% of the cohort for the triple award. In conclusion, Mr Januszewski expressed the hope that the assessment for this award would be grade-related, as otherwise his students would suffer.

3 Mike Petrus, Head of Science, Parkstone Grammar School, Poole

Parkstone Grammar School, Dorset, is an all-girls science college with a sixth form of about 340 students. Its facilities are variable, with laboratories in short supply and half of them not refurbished since the 1960s. Numbers taking A-levels, which have increased considerably over the past 15 years, are outstripping its ability to increase rooming capacity. It also runs an AS-level course for Key Stage 4 students. The science department is 50/50 male/female, with no obvious gender bias in any area. There is no overt 'marketing' of sciences in Years 10 or 11.

The presentation focused on the issues of accessibility and support for students and relevance.

3.1 Accessibility and support for students

Every student who was asked 'Why did you choose sciences?' cited support and approachability in the department. The department has its own pastoral policy, centred round the idea that the students are junior members of the department. There is a central departmental office in which the majority of the teaching staff is based; students are always welcome in the office and are encouraged to feel comfortable and able to approach staff for help from Year 8 onwards. Junior students see and hear Year 11, 12 or 13 students talking to staff about work; they see the mutual interest, humour, respect, and they sense the trust and support. It is not unusual for students to bring pastoral issues to their science teacher rather than their form tutor.

Many students choose science post-16 even though they may not feel it is their strongest subject, knowing that they will always be supported. Such students often achieve higher grades than their predictions from YELLIS or ALIS.[1]

Mechanisms for support include:

- a half-termly assessment summary for all students in the main school: a snapshot 1–4 rating indicating progress or lack of it, which triggers either reward/praise or a discussion of problems;
- half-termly one-to-one tutorials for sixth formers in each science subject;
- a 'cause for concern' system whereby teachers can inform science heads of department if they feel input from a third party is useful; and
- a 'never be afraid to ask' ethos, reinforced verbally and through room displays.

Support also includes high standards of discipline, including staff checking uniform, appearance, equipment, etc, and a rigorous department-based behaviour-management system.

In essence the department acts like a school within a school, integrated with and influencing whole-school policy.

These measures encourage uptake because:

- young people like to know that those who are meant to be in charge are in charge, and are capable/fit to be so;
- they see their science teachers working as a team, supporting one another; and
- they are confident in the safety of this controlled learning environment and so are not afraid to take risks in their learning (eg by giving the wrong answer to a question).

3.2 Relevance

When students were asked 'What was it about GCSE/Key Stage 3 that made you choose A-level science?', typical responses were 'We learnt more than just what was on the syllabus', or 'You made it interesting by teaching us about the history/people involved'.

1 YELLIS (Year 11 Information System) and ALIS (A-level Information System) are projects providing performance indicators for students run by the Curriculum, Evaluation and Management Centre, University of Durham.

Relevance in science education is a double-edged sword. One of the flaws of the inclusion of relevance in any science curriculum is that historically it has not reflected real life in, say, the inner cities. Moreover, some of the most exciting and awe-inspiring ideas in science are not particularly relevant to the average teenager's everyday experience, but these are often the ideas that capture the imagination when described by a teacher with a gift for storytelling, and for providing activities that allow students to grasp these great ideas.

Another problem is that much of the science that is being made 'relevant' is centuries old. It can be more engaging for students to learn the stories of the great scientists involved in the discovery of these ideas than to try to make them seem relevant to modern life. Children are constantly seeking the exciting and the extraordinary; if the science has to be relevant it can also be made recent and exciting – for example, experiments involving the synthesis of liquid crystals, which students can link to the ICT devices they use every day and are being manufactured on a large scale in industry, possibly an industry in which their own parents are employed.

We need to be absolutely clear about what we mean by relevance and how we apply it. Key questions that need to be asked are:

- who decides what is relevant?
- what definition of 'relevant' is being applied in the writing of courses?
- why can't students be asked what their science lessons should let them learn?

Confronting the issues discussed above from the earliest possible stages has, over the years, contributed to a steady growth in the A-level uptake of science at Parkstone, and these principles will be reflected in the new GCSE courses at the school. In concluding, the hope was expressed that they would be considered by all interested and influential bodies as they review their A-level and 16+ provision over the next two years.

4 Dave Kelly (Assistant Head) and Bethan Riddick (Head of Science), The Kings of Wessex Community School, Cheddar

4.1 The school

The Kings of Wessex Community School is a 13–18 specialist technology college in the Cheddar valley with a fully comprehensive intake of about 1200 students, including 300 in the sixth form, and a large science department of 13 teachers. The facilities are good but the department has recently outgrown the number of laboratories. In the past few years GCSE science results have been slightly better than average. At A/AS-level biology, chemistry and physics are among the five most popular subjects, taken by an average of about 30% of the intake, and about 60% of students choose at least one science subject.

The school has a very inclusive approach, accepting students with a wide range of ability into A-level, largely from the school's own cohort. Students with grades as low as double Cs in double science are given special support and closely monitored, especially in the first year.

4.2 Courses and enrichment activities

Course specifications are chosen to suit the students, who enjoy being able to choose a module (eg particle physics or gene technology) that interests them. The Salters' course in chemistry is very motivating for students of all abilities, and the most able students enjoy researching beyond the specification, spending a great deal of extra time in the laboratory.

The department runs a number of enrichment activities, including science clubs, master classes for Years 7 and 8, visits to local industry, visiting speakers and topical demonstrations (eg to observe the transit of Venus). It is a very friendly department, with a strong team, including three enterprising technicians, and a thriving atmosphere. In response to a questionnaire asking students what they liked about science at the school, the students cited the facilities as an important factor.

4.3 Reasons for success

4.3.1 Specialist approach

All teachers teach almost exclusively within their specialism, giving continuity and self-confidence to students, and all teach A-level. This approach has enabled the school to recruit four specialist physics teachers. In addition all teachers are enabled to attend courses to update their subject knowledge. Quality of teaching was another factor cited by students as influencing their choice of science.

All students take double-award science, but recently triple science was offered to the top 10% as part of the specialist schools programme, and this has been very successful, contributing to an increase in take-up at A-level.

4.3.2 Emphasis on practical work

Specialist teachers have more confidence to do demonstrations, and new staff are given support until they gain experience. Students enjoy practical work at GCSE and look forward to doing more at A-level. Chemistry experiments are especially enjoyable and motivating for students.

4.3.3 A positive culture towards science

Science has a high profile throughout the school, with teachers involved in a wide range of activities (including sports and foreign exchanges), and this very positive attitude is valued and supported by students.

Accessibility and support is an additional factor, as science is perceived as difficult and students need to feel supported. The school runs revision courses and various supportive clinics, and students know that they can ask for help on an informal basis whenever they need it. Potential A-level students are given guidance, support and encouragement, including an open evening for students and parents in January and personal interviews with senior staff.

5 Session summary

Drawing on the three case studies and his discussions with colleagues in these and many other schools over the last two years, Bob Ponchaud presented the following summary of the factors that do and do not seem to contribute to success in science and an increased take-up post-16.

5.1 What might help

- Specialist teaching of disciplines (but no data on this appear to be available for 11–16 schools).
- Separate teaching of disciplines, whether within a double-award or triple-award curriculum, by highly committed, suitably qualified and inspiring teachers.
- Positive perceptions of science post-16, which are as important to students as their experience pre-16.
- A variety of teaching approaches within a known ‘package’.
- Good careers information, from an informed standpoint which recognizes that a career in science does not just mean working in a laboratory.
- A success culture which balances challenge with ‘can do’, breeding more success.
- Resources that are fit for purpose and create a modern image.
- Wider involvement of science staff in school activities, creating a perception of science teachers as interesting people who ‘have a life’.
- Teaching that takes account of gender differences, eg physics teaching that is less ‘male’ (as in the all-girls Parkstone Grammar School).

5.2 What seems to help

- State-of-the-art facilities (although the experience at The Thomas Hardye School is that they are a factor).
- Gender models, eg female physics teachers.
- A curriculum based on relevance at the expense of challenge (either pre- or post-16).
- Choice of A-level specification.

6 Questions and discussion

Q. Many of the ideas emphasized in the case studies related to the run-up to GCSE. What strategies would you suggest for a sixth-form college, which does not have the advantage of building up relationships with its students before they start A-level?

A. ***Given time, we would have looked at both sixth-form colleges and 11–16 schools, but there are ways of communicating with feeder schools, and an informal network whereby students in those schools can find out what the older students think of their experience.*** The main strategy is probably to facilitate this network of communication as much as possible.

Q. How do you respond to, say, sociology teachers who see their best students being creamed off post-16 by the scientists?

A. ***Recruiting A-level students is a competitive business, and especially sensitive in a specialist science college where it is important to demonstrate that the specialist status benefits the whole school.*** We try not to over-market the subject but simply promote it as it is, with open evenings that show students what they will do if they take the course.

Q. Could you say more about what you mean by practical work, and what limitations there are, and how important practical work is in encouraging students to carry on doing science?

A. ***Practical work is essential to A-level science, and also important lower down the school.*** Students find it motivating and interesting, although they dislike the standard GCSE coursework because of the assessment hoops it involves. What they really enjoy is short, sharp practicals in class, to illuminate what they are doing and enable them to find out new things.

Q. Is the take-up of science at A-level in sixth-form colleges worse than in all-through schools? If so, it is a cause for concern for teachers in 11–16 schools.

A. ***There are no centrally available data on this, and if it is possible to carry out further case studies it will be essential to identify 11–16 schools that believe they are doing well in terms of their students continuing with science post-16, and have some data to prove it.***

6.1 Other notable remarks of participants

- If non-physicists are to teach physics it is important to recognize that they might not be fully equipped to do so after one year's initial teacher training, especially given that the PGCE does not address subject knowledge. Schools will have to give these teachers extra support in the first few years until they develop the necessary confidence.

- The experience of the case-study schools is of great interest not only to other science teachers but also to teachers of other science subjects, such as geology.

Breakout sessions and participants' feedback

Breakout group discussion session

For this session participants were divided into eight groups to discuss and formulate responses to five key questions designed to synthesize the evidence presented. The main responses to each question are summarized below.

Question 1.
What does the group feel is the one most striking point made this morning and/or the most important question raised?

1.1 Recommendations
Research is needed in the following areas:

- comparative retention rates in science and other subjects;
- the reasons why biology is so attractive – is this because it is (perceived as) 'easy'?[1]
- the differences between 11–16 and 11–18 schools, eg whether familiarity and/or students' relationship with teachers are significant factors in post-16 take-up.

There is a need to:

- clarify the meaning of 'relevance';
- work with successful schools to disseminate successful strategies and best practice;
- broaden endpoints for students with science A-levels;
- consider the school (etc)/university (etc) interface, given that about 40% of all pupils go on to more full-time education;
- provide incentives and rewards for non-specialists to become specialists (eg accreditation of continuing professional development (CPD) in other subjects through Chartered Science Teacher/Professional Standards);
- balance specialist knowledge with effective pedagogical practice;
- consider how to tackle students' perception of the difficulty of science at A-level versus others' perception of sciences as becoming more easy;
- ensure that careers advisers have science experience so that they can provide well-informed advice;
- encourage science teachers to promote their subject;
- identify and promote the learning value of science for students who will not do any science post-18; and
- clarify whom we want doing science – some future technicians or the whole school population?

1.2 Strong messages
Participants stressed the importance of:

- variety in practical work;
- a subject team;
- subject confidence and enthusiasm in teaching; and
- appropriate assessment regimes.

There was also a need to recognize that:

- the problem of post-16 take-up lies to some unknown extent with the wider social image of science;
- the problem is common to the developed world in general, not just the UK; and
- the post-16 population is no longer homogeneous.

1.3 Other notable remarks of participants

- Teachers have a key role, and there will be a big problem if there are fewer science teachers in the future because of demographic changes.
- The main problem is a lack of teachers, not poor teaching standards. Financial incentives are starting to make a difference, though the balance of sciences is still a problem. There is a need to ensure that funding is not diverted by a change of government/Secretary of State.
- There is a lack of unanimity on the science curriculum at GCSE.
- Massive resources are put into the Key Stage 2/3 transition, but not into the pre-16/post-16 transition.
- The whole basis of Key Stage 4 seems to be that science is (only) about investigation. Schools with sixth forms have a different attitude – there is a need to feed this back lower down the school.
- Should we be encouraging other ways into science beyond the traditional A-level routes? Are there other ways of achieving post-16 science?
- There is a need for a key post-holder for science in the DfES.

1 It is notable that the Biosciences Federation's report *Enthusing the next generation* notes that according to a recent survey, it is harder to gain an A in A-level biology than in any other science based on comparisons of students' A-level grades with their GCSE results. See Hill, P 2004 Study calls for grading reform, *Times Higher Education Supplement*, 3 September, pp. 2–3.

Question 2

What do you think are the most important reasons to encourage young people to study science post-16 and which of these are the most important for government policy-makers in pursuing their commitment to the ten-year framework ambitions?

The most important reasons given included the following:

- Economic: for the country to generate economic wealth by world-class science requires both a sufficient flow of scientists and more science teachers and technicians. There is a need to invest more in recruiting high-quality science teachers in schools, eg through STEM (science, technology, engineering and mathematics) initiatives.
- Functionally literate citizenry: public perception and understanding of science is as important as economic needs and we need science and mathematics for everyday use. Studying science helps people to become well-informed citizens ('science for life'), promotes a wider understanding of other disciplines and contributes to young people's personal development, by fostering new skills and ways of thinking.
- Cultural need: there is a basic requirement to provide young people with culture – ie the same reasons why we teach Shakespeare or history.
- Enjoyment of science.
- Financial: studying science leads to good careers.

It was also observed that:

- the government is most able to do something about teacher supply;
- that good teachers, or having a parent who is a scientist, are likely to play a part in encouraging young people to study science; and
- partnerships between industry and education should be more than simply a matter of industry giving schools money: industry needs to find out more about education.

Question 3

If you had to set a goal for improving post-16 science over the next eight years, what would it be?

- Concentrate on underrepresented groups in science, eg ethnic minorities, women in physical sciences.
- Bring science and mathematics closer together as subjects.
- Provide better careers advice and career paths, with the necessary resources and support.
- Provide shorter courses and more choices.
- Make SPU (science for public understanding) a legitimate and compulsory science subject.
- Keep routes into science open for less able students.
- Make courses enjoyable.
- Stop making changes to curricula.
- Reach where we were 15 years ago (ie reverse the 35% overall drop in physics entries since 1991), with an annual target of a 3% increase in entries. The government should be threatened, bullied and embarrassed into achieving this.
- Encourage undergraduates to study science post-graduation.
- Increase the numbers of science teachers recruited.
- Increase CPD opportunities for teachers.
- Do something sustainable – everything is fixed-term, initiatives start and end, with no follow-through.

Question 4

Which of the educational reforms talked about today, school strategies, or other activities, have had or will have the most impact (positive or negative) on achieving the ambitions just discussed?

The following reforms/strategies/activities were considered as having or likely to have a positive impact:

- improving transitions across each phase (eg pre-/post-16);
- ensuring assessment does not drive the agenda;
- improving school infrastructure, eg laboratories, and providing modern resources;
- providing scientific role models in schools to raise profiles;
- developing a marketing strategy for science;
- improving media images of science;
- investing in initiatives to provide resources and support for teachers, and incentives for PGCE recruitment;
- obtaining up-to-date data on teacher supply, including those teachers not currently working and those shortly to return;
- giving teachers the confidence and ability to take risks in teaching, so that they in turn can give students the confidence to risk getting things wrong;
- telling the government what teachers are doing well;
- providing resources and support for improved careers advice;
- curriculum changes at Key Stage 3, GCSE and A-level;
- increased practical work;
- reducing class sizes (from 30 to, for example, 24), which would make discipline easier – discipline is essential for practical work;
- celebrating schools' successes ('carrot' approach) instead of the 'stick' approach of Ofsted, given that successful schools are more successful in recruiting physics specialists.

The disparity in the regard with which academic and vocational science courses are held has a negative impact.

Question 5

Given the current state of affairs, which group of people will have the most difference to make to moving these issues forward?

It was considered that learned societies in general, and the Royal Society in particular (which should look closely at the school/university interface) had a key role to play. It was also suggested that the 'Russell Group' of universities, the Royal Society, the Research Councils (RCs) and the Wellcome Trust should work together as a group. It is expected that the RCs' Science in Society (SiS) strategy, which is currently being reviewed, will suggest that it is the responsibility of the RCs to lobby at the highest level.

Other groups/organizations cited included:

- those working with careers advisers;
- teachers;
- awarding bodies and the QCA;
- industry.

Feedback from conference evaluation forms

Participants were invited to complete an evaluation form at the end of the conference. The following distillation represents best the comments made.

1 The most important message you are taking away from the conference, and other observations

'There is a need for consensus among science and science education committees in order to influence education policy and reduce unhelpful government interventions and untried innovations.'

'Teachers make a difference, dependent on their enthusiasm, involvement and subject content. They need a wider experience to be able to attract more students post-16, but with a whole picture in mind.'

'The importance of strong specialist teaching, linked into strong teams of teachers, cannot be overemphasized.'

'There is a need for more research into factors that influence subject choice, and school factors associated with decreased average participation in post-16 science.'

2 Actions you would like to see the Royal Society take

'Give the issues discussed in the conference a high priority and lobby key agencies, ie the government, HEFCE, specialist agencies, teachers' organizations, QCA, etc.'

'Keep lobbying the government to listen more to science teachers/schools/professional bodies. We need to be much more creative with encouraging people into "science".'

'Use its insight in terms of policy clout, but not on its own. The Council [of the Royal Society] should have cross-body support for policy input and development.'

'Collaborate with others to back the necessary research and development.'

'One research question not mentioned concerns the relative success of biology-related courses, eg forensic science. This should not be dismissed, rather investigated.'

'Lobby for less assessment-driven specifications in all science courses. Review of curriculum should be wider than just changing specifications.'

'Be much more actively involved in science educational policy. Keep an eye on this issue. Commercial exam boards/QCA are now the gatekeepers on assessment, with the rigorous nature of exam boards, which used to lie with universities, now lost.'

'Pursue ways of raising the prestige of science teaching.'

'Advise careers advisers and science teachers of the vast variety of careers that studying science can lead to and keep them up to date. Possibly produce a CD/DVD for showing to Year 9/10/11 students.'

'Act as a "one-stop shop" for organizations offering help/funds/advice/speakers to schools.'

'Help to enable a clear agenda to answer the question "what do we want from science education?"'

'To be able to direct students (Year 10/11 – before options) to a website or websites on what people have done with science A-levels/degrees. Information about Nobel programmes, etc, is easy to obtain. What they need is more about young people (twenties to thirties) and what they are doing. The famous scientists are too remote.'

Appendices

Appendix 1 List of participants

Peter Adamczyk	Sussex School of Education, University of Sussex
Yaa Adjei	The Wellcome Trust
Hannah Baker	The Biochemical Society
Jenny Baker	Department for Education and Skills (DfES)
Patrick Barmby	Curriculum, Evaluation and Management (CEM) Centre, University of Durham
Kathy Barrett	Careers Group, University of London
David Boak	Director Communications, The Royal Society
Peter Bodily	Uppingham School, Rutland
Joe Brock	The College of Richard Collyer, West Sussex
Jenifer Burden	Twenty First Century Science, Science Education Group, University of York
Peter Campbell	Nuffield Curriculum Centre
John Coad	Pfizer
Nigel Collins	King Charles I School, Worcestershire
Sarah Cooney	Society of Chemical Industry
Andrew Davidson	Institution of Civil Engineers
Peter Davies	Institute of Materials, Minerals and Mining (IoM^3)
Rosemary Davies	Campaign for Science and Engineering in the UK (CaSE)
Steve Davies	Educational Services, Worcestershire County Council
Justin Dillon	Department of Education and Professional Studies, King's College London
Bob Ditchfield	The Royal Academy of Engineering
Jim Donnelly	Centre for Studies in Science and Mathematics Education, University of Leeds
Patrick Dowling	Chair, Royal Society Education Committee CBE FRS
Alan Evans	Learning and Development Unit, School of Social Sciences, Cardiff University
Adrian Fenton	Association for Science Education (ASE)
Sue Flanagan	Forest Gate Community School, London
Ken Gadd	4 Science
Michael Grove	School of Mathematics, University of Birmingham
Debby Horsman	Wootton Upper School, Wiltshire
John Howson	Education Data Surveys Ltd, Oxford
Mike Januszewski	The Thomas Hardye School, Dorset
Edgar Jenkins	Centre for Studies in Science and Mathematics Education, University of Leeds
Jackie Johnston	The College of Richard Collyer, West Sussex
Paul Jones	Institute for Employment Research, University of Warwick
Dave Kelly	The Kings of Wessex Community School, Somerset

Suzanne King	People, Science & Policy Ltd
Peter Loader	St Bede's College, Manchester
Dominic McDonald	Engineering and Physical Sciences Research Council (EPSRC)
Paul Malpass	National Science Learning Centre, York
Jessica Meller	Science & Technology Department, Association of the British Pharmaceutical Industry (ABPI)
Robin Mellors-Bourne	Commercial Business Development Director, Careers Research and Advisory Centre (CRAC)
Robin Millar	Department of Educational Studies, University of York
David Montagu	The Royal Society
Annette Montague	Youth Sport Trust
Andrew Morris	National Education Research Forum (NERF)
Andrew Morrison	Science and Society Programme, Particle Physics and Astronomy Research Council (PPARC)
Mark Orrow-Whiting	Science Consulting Team, Qualifications and Curriculum Authority (QCA)
Ginny Page	The Royal Society
Mike Petrus	Parkstone Grammar School, Dorset
Bob Ponchaud	Independent Consultant, former HMI with responsibility for science
Richard Pring	Department of Educational Studies, University of Oxford
Michael Revell	Secondary National Strategy, Capita SES
Sarah Revell	The Royal Society
Bethan Riddick	The Kings of Wessex Community School, Somerset
Kathryn Roberts	Royal Society of Chemistry
Pamela Robinson	Centre for Education and Employment Research, University of Buckingham
Daniel Sandford-Smith	Institute of Physics
Peter Saunders	The London Mathematical Society
Jean Scrase	4 Science
Andy Segal	John Kelly Girls' Technology College, London
Alice Sharp Pierson	The Royal Society
Simon Singh	Author, journalist and TV producer
Emma Smith	Department of Educational Studies, University of York
Samantha Sookdeo	Sydenham High School, London
Almut Sprigade	Education Data Surveys Ltd, Oxford
Kay Stephenson	The Royal Society of Chemistry
Juliet Strang	Villiers High School, Middlesex
Frances Stratton	South Wiltshire Grammar School for Girls
Nigel Thomas	The Gatsby Charitable Foundation
Clare Thomson	Bromley High School, Kent
Vanessa Thorogood	Institute of Mathematics and its Applications (IMA)
Nick von Behr	The Royal Society
Alison Ward	Sutton High School, Surrey
Nicola Wilberforce	Esher Sixth Form College, Surrey
John Williams	The Gatsby Charitable Foundation
David Winstanley	Science, Engineering, Manufacturing Technologies Alliance (SEMTA)
Alison Wolf	Department of Management, King's College London
Ruth Wright	Engineering Council

Appendix 2

Royal Society conference
Increasing uptake of science post-16
Friday 10 March 2006

Programme

09.30–10.00	Arrival and registration (including refreshments)
10.00–10.10	Chairman's introduction Professor Patrick Dowling CBE FRS, Chair, Royal Society Education Committee
10.10–10.50	From pupil to scientist – more or less? Findings and indications from the available data Professor John Howson and Dr Almut Sprigade, Education Data Surveys Ltd
10.50–11.05	Discussion
11.05–11.20	Tea and coffee
11.20–12.00	Educational reform and the take-up of science post-16 Professor Jim Donnelly and Professor Edgar Jenkins, Centre for Studies in Science and Mathematics Education, University of Leeds
12.00–12.15	Discussion
12.15–13.15	Lunch
13.15–14.20	Lessons by example: showcasing success in schools and what may be learnt from this Mr Bob Ponchaud, Independent Consultant, former HMI with responsibility for science Mr Mike Januszewski, Head of Science, The Thomas Hardye School Mr Mike Petrus, Head of Science, Parkstone Grammar School Mr Dave Kelly and Ms Bethan Riddick (Assistant Head/Head of Science, The Kings of Wessex Community School)
14.20–14.35	Discussion
14.35–15.50	Breakout group discussion sessions, with tea and coffee break
15.50–16.00	Chairman's concluding remarks
16.00	Close

Further copies of this report may be obtained by sending a self-addressed and stamped envelope to: Education Team, The Royal Society, 6–9 Carlton House Terrace, London SW1Y 5AG.

This report was reviewed by a panel chaired by Professor Martin Taylor FRS, Vice-President, the Royal Society, and including Dr Mariann Bienz FRS and Professor Michael Reiss, Head, School of Mathematics, Science and Technology at The Institute of Education, University of London.

The Royal Society
6–9 Carlton House Terrace
London SW1Y 5AG
tel +44 (0)20 7451 2561
fax +44 (0)20 7451 2693
email education@royalsoc.ac.uk
www.royalsoc.ac.uk

Founded in 1660, the Royal Society is the independent scientific academy of the UK, dedicated to promoting excellence in science.

The objectives of the Royal Society are to:

- strengthen UK science by providing support to excellent individuals
- fund excellent research to push back the frontiers of knowledge
- attract and retain the best scientists
- ensure the UK engages with the best science around the world
- support science communication and education, and communicate and encourage dialogue with the public
- provide the best independent advice nationally and internationally
- promote scholarship and encourage research into the history of science.

Issued: July 2006