Science education from 14 to 19 : government response to the Committee's Third Report : sixth special report of session 2002-02 / House of Commons, Science and Technology Committee.

House of Commons
Science and Technology Committee

SCIENCE EDUCATION FROM 14 TO 19: GOVERNMENT RESPONSE
to the Committee's Third Report

Sixth Special Report of Session 2001–02

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SIXTH SPECIAL REPORT

The Science and Technology Committee has agreed to the following Special Report:

SCIENCE EDUCATION FROM 14 TO 19: GOVERNMENT RESPONSE TO THE COMMITTEE'S THIRD REPORT OF SESSION 2001-02

1. The Science and Technology Committee reported to the House on Science Education from 14 to 19 in its Third Report of Session 2001–02, published on 11 July 2002 as HC 508-I.

2. The Government's response to the Committee's Report was received on 4 September 2002 in the form of a memorandum to the Committee. It is reproduced as Appendix 1 to this Special Report.

3. On 2 October 2002, a response was received from the Qualifications and Curriculum Authority. This is reproduced as Appendix 2 to this Special Report.

4. On 30 September 2002 a response was received from the Joint Council for General Qualifications. This is reproduced as Appendix 3 to this Special Report.

5. We publish these responses without comment, so that they are publicly available without delay. We intend to ask the Schools Standards Minister to give evidence on the Government Reply, which we find unsatisfactory.

APPENDIX 1

THE GOVERNMENT'S RESPONSE

The Select Committee's recommendations and conclusions are in bold text and numbered as per the "List of Recommendations and Conclusions".

The Government's response is in plain text.

This Government places great importance on the value of science education. Science affects all our lives. We must ensure that all young people receive a sound basic understanding of science and are equipped to deal with the social and ethical issues it raises. For those who go on to study science at higher levels they must have a firm foundation on which to build. The Government welcomes this report and it is pleased to be able to report progress in many of the areas identified by the Select Committee. We recognise that there is continuing work to create and maintain an innovative, inspiring and relevant science curriculum for all 14 to 19 year olds.

A response to each of the recommendations and conclusions is provided below.

The GCSE curriculum

1. **It is clear that the major problems lie at key stage 4. ... Many students lose any feelings of enthusiasm that they once had for science. All too often they study science because they have to but neither enjoy nor engage with the subject. And they develop a negative image of science which may last for life.**

In July we published our response to Sir Gareth Roberts' Review of the Supply of Engineers and Scientists as part of our comprehensive Science and Technology Strategy. The 2002 Spending Review announced the largest sustained growth in science spending for a decade – £1.25 billion extra a year by 2005-06. We will enhance technology, mathematics and science education in our schools, colleges and universities. We accept that more needs to be done to inspire pupils and to make the science curriculum at 14 - 16 more exciting and relevant. The science GCSE needs to encourage a wider range of pupils to continue study in this area. We agree with the Roberts Review that this will be crucial in increasing interest in the physical sciences, especially among girls and ethnic minorities. The Government is piloting a new Science GCSE and will review it in this context as soon as possible.

The Government is determined to transform secondary schooling for all pupils across the curriculum. Already, with the commitment of teachers and pupils, there have been huge improvements at primary level since 1997 and we have consulted widely on our plans for learning post 14. We are tackling one of the long neglected and toughest challenges facing schools; the middle years between 11 and 14 (Key Stage 3). We believe the middle years to be critical, and without real progress, the gains achieved at primary level will be dissipated.

The Government's National Strategy for Key Stage 3 is designed to raise standards by strengthening teaching and learning across the curriculum for all 11 - 14 year olds. Science teaching at Key Stage 3 demands versatile teachers and imaginative approaches to bring it to life to capture pupils' enthusiasm, develop their interest and give them a thorough understanding of the subject. The science strand of the strategy was launched in May 2002 and will be implemented in classrooms from the start of the autumn term 2002. It will improve the quality of teaching and learning in classrooms by investing in teachers' continuing professional development. It will promote the teaching of engaging, challenging and inspiring lessons and establish high expectations for pupils. Key Stage 3 is the bridge that will consolidate the achievements made at primary level, result in further success at Key Stage 3 itself (we have set a challenging target for 80% of pupils to reach level 5 and above in science at the end of Key Stage 3 by 2007), and provide a springboard to further success across the curriculum at GCSE and beyond.

2. **The GCSE science curriculum is over-prescriptive. This puts students off science because they do not have the flexibility to explore areas which interest them. It kills the interest in science which may have been kindled at primary school.**

The current National Curriculum KS4 Programme of Study (PoS) for science and the derived GCSE specifications came into effect for GCSE courses in September 2001. The accreditation of the awarding body specifications based on this revised PoS ensured that any repetition of material from earlier key stages was removed. As a result current GCSE specifications are significantly reduced in content from their predecessors.

The accreditation process also ensured that awarding body specifications reflected the broader approach to scientific enquiry and up-to-date examples of science and its applications.

The first cohort of pupils studying the revised KS4 science curriculum will sit their GCSEs in summer 2003. It is still too early to say whether the changed curriculum will result in more positive attitudes towards science among 14 -16 year olds.

The Green Paper *14 - 19: extending opportunities, raising standards* proposed that the programme of study be further reviewed and updated to achieve a core of science relevant to all learners, and that core be built into a wider range of qualifications.

3. **If students are to be able to see the relevance of their school science, the curriculum should include recent scientific developments.**

The vision for Science Year is: 'To improve, for ever, the way in which science is viewed, taught and studied so that young people can engage more creatively with a future that is increasingly scientific and technological.' Because of its success in attracting key corporate partners, engaging the science community and bringing up to date equipment into all schools, we have recently announced an extension of the Year to July 2003. We will encourage schools to use the extensive Science Year on-line resource bank to enhance teaching in science. Many interesting classroom resources use recent scientific developments to explain ideas in science and, as the Committee's report acknowledges, there are opportunities in the Key Stage 4 curriculum to enliven teaching using these resources. The pilot GCSE is being designed around the concept of 'key ideas' to explore modern science and to explain fundamental scientific principles.

4. **Students want the opportunity to discuss controversial and ethical issues in their science lessons, but this happens very rarely. Engaging in debate is an approach to teaching that is unfamiliar to many traditional science teachers; and the way that science is assessed means that students are not rewarded for thinking for themselves or for contributing their own ideas.**

There are opportunities to discuss controversial and ethical issues in the science classroom already within the science curriculum. For example, within the National Strategy for Key Stage 3, the *Framework for teaching science: Years 7, 8 and 9* underpins the training which science teachers have already received and includes examples of contemporary science relevant to the Key Stage 3 programme of study. The framework promotes high quality direct, interactive teaching. This is a two way process in which all pupils are expected to play an active part by answering questions, working collaboratively together during scientific enquiry, contributing points to discussions, and explaining and demonstrating their methods, conclusions and solutions. Science teachers will be encouraged to ensure that all pupils contribute to discussions, ask for explanations, are listened to carefully and responded to constructively to take forward their learning, challenge their assumptions and encourage them to think creatively. Many secondary science teachers cover the 11-16 and post 16 age ranges. We anticipate the preparation, training and support provided by the Key Stage 3 Strategy will have a beneficial effect on science teaching for all secondary pupils.

We are also analysing the results of the Science Year Young People's Review of the science curriculum to inform our thinking on Key Stage 4 development, particularly the new pilot GCSE. We will draw on the Wellcome Trust's *Valuable Lessons* report, which examined teachers' own views on teaching socio-scientific issues. We acknowledge however, that this is unfamiliar territory for some secondary science teachers. In our response to the Roberts review, we reiterated our intention to establish a National Centre for Excellence in Science teaching and we are delighted that the Wellcome Trust has agreed to enter a partnership to deliver the Centre. We are jointly developing proposals and anticipate an announcement on our plans later on in the autumn. However, we can say at this stage, that we are looking very closely at the priorities for the Centre and have identified the teaching of controversial and ethical issues as an important area for development.

5. **During GCSE students repeat much of the science that they have covered in key stage 3. Inevitably they find this boring.**

The National Curriculum, including science, was revised in 2001. New GCSE criteria were produced based on the revised Programmes of Study, which ensured that any repetition of material from earlier key stages was removed. Current GCSE specifications are significantly reduced in content, reflect the broader approach to scientific enquiry and up-to-date examples of science and its applications and address the issue of repetition at KS3 and KS4.

The Government believes that the science strand of its Key Stage 3 Strategy will enable teachers to deliver engaging, challenging and inspiring lessons at the same time as setting high expectations for pupils' achievement. It believes this achievement will be consolidated, rather than dissipated at Key Stage 4. In particular, the *Framework for teaching science: Years 7, 8 and 9* defines continuity as the consistency in expectations and teaching approaches between, as well as within, key stages. It acknowledges that good continuity extends pupils' experiences without unhelpful repetition. The framework emphasises that pupils' progress from early knowledge of scientific ideas, to a deeper and broader understanding, needs to be planned and sequenced carefully. Although the Key Stage 4 curriculum is not directly affected by the National Strategy for Key Stage 3, the

current Programmes of Study, Key Stages 1 - 4, are designed to encourage progression through all key stages.

Practical and fieldwork

6. **The science curriculum at 14 to 16 aims to engage all students with science as a preparation for life. At the same time it aims to inspire and prepare some pupils to continue with science post-16. In practice it does neither of these well.**

Over 80% of pupils currently follow a course leading to a double award GCSE that provides a secure base for progression to more advanced study in a range of science subjects. The Green Paper *14 - 19: extending opportunites, raising standards* outlines how the QCA will pilot for 2003 an innovative structure for GCSE science engaging pupils with contemporary scientific issues and focussing on their role as users and consumers of science. The Programme of Study will be updated to provide a core of science relevant to all learners.

7. **We endorse the view of the Field Studies Council that fieldwork should be strongly recommended in all courses.**

8. **In our view, practical work, including fieldwork, is a vital part of science education. It helps students to develop their understanding of science, appreciate that science is based on evidence and acquire hands-on skills that are essential if students are to progress in science. Students should be given the opportunity to do exciting and varied experimental and investigative work.**

Response to recommendations 7 and 8

The wider issue of practical work is vital for science. It is essentially an investigative subject, using evidence to support or disprove theories. We agree practical work needs to excite and interest students. This is another key area emerging from our work on the National Centre for Excellence and also one where the Science Year resource bank will be significant.

At Key Stage 3, the *Framework for teaching science: Years 7, 8 and 9* emphasises that scientific enquiry has a central place in science because it helps pupils to understand how scientific ideas are developed, and because the skills and processes of scientific enquiry are useful in many everyday applications. The framework stresses that the teaching of scientific enquiry should use contexts taken from the whole programme of study and includes a range of domestic, industrial and environmental contexts. Science teachers will also receive training, advice and guidance on effective fieldwork.

The 'Growing Schools' initiative is working to encourage schools to make more use of the 'outdoor classroom' right across the curriculum, from Early Years through to post 16. The Government recognises the value of learning away from the classroom in stimulating interest, developing hands-on skills and having first hand experiences. In developing Growing Schools, case studies were collected to determine where in the curriculum learning can, and does take place outdoors. Science is one of the top subjects studied through, for example, enhancing school grounds to create study areas, or by visits to external sites, such as commercial farms and field study centres.

Coursework

9. **The way in which coursework is assessed for GCSE science has little educational value and has turned practical work into a tedious and dull activity for both students and teachers.**

See response to recommendation 28

Use of ICT

10. **ICT may have the potential to revolutionise science teaching but the evidence would suggest that it has not yet had a real impact in many schools.**

11. **There needs to be a clearly defined role for ICT within science teaching if it is to have any real educational value.**

Response to recommendations 10 and 11

We agree that ICT should be used intelligently to support teaching and learning. The enormous potential of ICT means that, for the first time, it is becoming possible for each pupil to learn in a way and at a pace that suits them. Curriculum On-Line is a key element of our commitment to the development of a thriving dynamic market for free and commercial digital learning resources for teachers to use in raising standards in the classroom. It will offer an on-line catalogue of certified resources searchable by Key Stage and topic. These resources will be provided by publishers, teachers and public sector bodies such as museums and galleries.

ICT, used properly, is a powerful tool, and we have already cited the use of interactive whiteboards in our memorandum to the Committee. Used well, ICT in science lessons enables pupils to gain information that could not be obtained otherwise. (For example, through data logging, pupils can capture data involving very fast, or very slow, changes and electronic measuring equipment removes the tedium of manual measuring and recording. This frees up time for discussion of the underlying science). The *Framework for teaching science: Years 7, 8 and 9* promotes the use of ICT in science lessons to enhance individual learning and to enhance the learning of a whole class.

In April 1999, £230 million (£180 million in England) of National Lottery money was made available through the New Opportunities Fund (NOF) programme to train UK serving teachers and school library staff in the maintained sector in the effective use of ICT in their subject or library work. The rationale for undertaking the training is to gain sufficient knowledge of ICT to use the medium effectively in the classroom. It is designed to bring the classroom teacher up to same skills level as those now entering the profession from teacher training institutes who will have undergone similar training. Although the last date to register for the training was 31 March 2002, training will continue to be delivered up until the end of 2003.

The training has been carefully structured to the individual teacher and is subject-specific at secondary level. Primary school teachers have access to more general training, which concentrates on the core National Curriculum subjects of English, mathematics and science. The NOF training can only be delivered by approved training providers who have had to pass rigorous selection criteria. This criteria includes an understanding of pedagogical issues as well as technical expertise in using ICT. Teachers have been encouraged in each case to make use of personal needs assessment materials, which form an integral part of the scheme, in order to maximise the effectiveness of the training.

According to the latest figures available for England, over 390,000 teachers have signed up for the training, of whom well over 240,000 have now completed it.

The training is not compulsory, but we recognise that most teachers would want to undertake it as part of their own continuing professional development (CPD). All the active providers – without exception – now meet the expected outcomes of the NOF programme, and there are a number of exemplary trainers working with teachers in the primary and secondary sectors and SEN.

We have also commissioned the development of further ICT training materials to be delivered online to support teachers' continuing professional development, this included materials in support of the Key Stage 3 Science strategy which have been piloted in selected schools. It is planned to make the KS3 Science strand available to teachers from Spring 2003.

The Government recognises that teachers may need further support to develop their teaching approaches to include the effective use of ICT in the science classroom, and this, as well as other innovative approaches, is part of our development work on the National Centre for Excellence.

Take-up post-16

12. **It would seem that students study science post-16 not because of science at GCSE but despite it.**

13. **It seems that recent reforms to post-16 education have not produced a significant increase in the number of students studying science.**

Gender

14. **We welcome the increase in the number of girls studying biology and chemistry to A level that has occurred since the introduction of compulsory balanced science to GCSE. In particular we are pleased that girls now make up 50% of A level chemistry entries. We are, however, concerned that physics remains an unpopular option with girls.**

15. **The falling number of boys choosing biology and chemistry A level is a matter for concern. The reasons for this need to be investigated further and we recommend that DfES fund research in this area.**

Response to recommendations 12 - 15

The Further Education Standards Unit will be developing Teaching & Learning frameworks for major curriculum areas, and Science is likely to be included, subject to the results of the consultation process, which is due to complete at the end of September 2002. The work will include consideration of all aspects of teaching and learning, including the delivery methods, the assessment methods, the syllabus content, and teaching materials.

GCSE specifications are aligned to the National Curriculum programmes of study for Science at Key Stage 4 and must meet the criteria produced by QCA. The criteria were produced following wide consultation, including with academics, practitioners and representatives of industry. Schools can currently offer pupils aged 14-16 one of three options, in conjunction with the National Curriculum programme of study in science: single

award science, leading to one GCSE; double award science, leading to the award of two GCSEs; or GCSEs in the three separate sciences of biology, chemistry and physics.

Schools are free to select the syllabus, or syllabuses offered by the awarding bodies which they feel best meets the needs and aptitudes of their pupils, and will engage them in the topic.

The Government agrees that the low take up of physics by girls, and the falling numbers in biology and chemistry by boys, are matters for concern. The Curriculum 2000 reforms will have an impact on boys' and girls' choices of subject combinations, and we will monitor how the trends develop. Changes to the specifications, such as a greater contextualisation of scientific problems, should encourage more students of both sexes to do science subjects.

The key to encouraging more students to take science subjects post-16 is to improve their perceptions of the sciences, and the usefulness in terms of careers, before they leave compulsory education. Science Year is a key initiative to encourage young people to continue their study of science beyond the age of 16. The Science and Engineering Ambassadors programme is bringing professionals to schools to enthuse pupils and make science more relevant.

The Government is determined to enhance students' science, maths and technology education, and so encourage students to continue with these subjects, through measures including:

- improving recruitment and retention of good science and mathematics teachers;
- establishing a National Centre of Excellence for Science Teaching; and
- capital investment in schools specifically targeted on school science laboratories.

The Government has extended the range of specialisms in the Specialist Schools programme. From September 2002 there will be 12 schools with the new Maths and Computing specialism and 24 with a specialism in Science. These schools will help to spread good practice in science teaching to other schools.

Gender related underachievement, and stereotypical views on subject/career choices, are being tackled through measures including:

- the Gender and Achievement section of the DfES' internet Standards Site provides information on resources and programmes;
- the Office of Science and Technology's Promoting Science, Engineering and Technology for Women Unit has produced a range of resources for attracting girls to science; and
- we are working with the Equal Opportunities Commission's 'What's Stopping You?' schools campaign to challenge stereotypes over science careers.

16. **The GCSE science curriculum fails to provide for the differing interests of boys and girls.**

We disagree with the Committee's conclusions arising from their analysis of the differing choices and attitudes between boys and girls. The Government is working to tackle under achievement at all stages of education and does not accept that the curriculum at any level disadvantages either boys or girls. The National Curriculum Programmes of Study are

specifically designed to be gender free. The views of boys and girls cited by the Committee suggest that more 'modern ideas' is what they are really asking for. The examples given reflect their differing interests, which can be catered for within the existing curriculum, as set out in our response to recommendations 3 and 4. However, in view of the Committee's concern in this area, we will appraise the need for gender issues to be further addressed in the design of the new science GCSE pilot. We also think that Science and Engineering Ambassadors will have an important effect on the career aspirations of both boys and girls. It is this that lies at the heart of the Committee's recommendation and we endorse the Roberts review finding that more young people of both sexes need to aspire to careers in science, technology, mathematics and engineering

Ethnicity

17. **We welcome the introduction of pupil level ethnic monitoring by DfES. We trust that the data will show the performance of different ethnic groups in science subjects and recommend that this information will be made public as part of DfES's annual statistics publications.**

18. **It would appear that some of the usual assumptions about the relative participation of men and women in science and engineering are simply not true in respect of ethnic minority students.**

Response to recommendations 17 and 18

The introduction of the Pupil Level Annual Schools Census (PLASC), and the creation of a National Pupil Database combining PLASC data with pupils' Key Stage and examination results will enable much more systematic analysis of how levels of achievement (overall and in specific subjects) vary by ethnicity and other pupil characteristics.

The Department will certainly be reviewing and extending its statistical publications in the light of these new data, and analyses by ethnic group are likely to feature prominently. However the new analyses need to be based on a careful examination of the data taking account of potential interactions between ethnic group and other attributes (such as gender, language, low income and special educational needs). As the Committee points out, some common assumptions may prove to be misconceived, and it will be important therefore not to perpetuate these assumptions by presenting ethnicity analyses in a simplistic one-dimensional way.

Data from the National Pupil Database will also be made available for bona fide educational research, much of which we would expect to include ethnic monitoring as an element.

Student perceptions

19. **Students may be dissuaded from studying science at A level if they think it will be harder work than other subjects and more difficult to achieve a high level grade.**

Response to recommendations 19 and 51

The current A level grading system is driven by reference to criteria based on the core knowledge, skills and understanding which candidates must demonstrate in a subject in order to achieve a particular grade. The appropriate grade standards for each subject are

determined through consultation with the individual subject communities. When QCA devised the subject criteria to which the most recent A level specifications conform, they relied heavily on advice from subject specialists from schools and higher education. The published grade descriptions of performance in each subject at grades A and E were likewise written in consultation with subject specialists, and the awarding bodies depend on the subject expertise of their senior examiners when writing specifications and question papers and marking and grading examinations. As regulator, QCA undertake a range of monitoring activities to make sure that awarding bodies comply with the regulatory criteria and codes of practice, to ensure quality, rigour and consistency of standards.

A norm-referenced system, where a set proportion of students receive each grade, was used prior to 1987. With this system the statistics might appear more "balanced", but they are less helpful in indicating the standard of attainment that had been reached.

As the Roberts review recognised, QCA gives considerable attention to the issue of inter-subject comparability, and will continue to monitor awarding body performance in this area. QCA are currently devising an additional programme of work in response to the recommendations of the independent panel report on maintaining A level standards. The report recommended that QCA addresses the area of inter-subject difficulty by focusing on the comparability of examination demand and the standards of performance expected of students in different subjects.

QCA recently piloted methodologies for analysing inter-subject comparability that allow for qualitative measures. So far, the outcomes have been promising in terms of validating the approach; more extensive conclusions will be available at a later date. QCA will be conducting a qualitative analysis of the comparability of examination demand and candidate performance between History and Geography at GCSE, AS and A level. The first stage of this work is due to start in Autumn 2002.

20. **The mathematical requirements, or students' perceptions of the mathematical requirements, of A level sciences puts students off choosing to study these subjects. This particularly applies to physics.**

See response to recommendation 50.

21. **Students' awareness of scientific careers and the value of transferable skills gained through science would appear to be limited.**

See response to recommendation 55

Vocational pathways

22. **The vocational options in science are not yet attracting students. More should be done to provide attractive vocational courses and to ensure that students are well aware of the potential value of the qualifications for a range of future careers.**

There is a substantial amount of work currently in progress to support the Government's aim of establishing greater esteem for vocational qualifications.

The development of the National Qualifications Framework ensures the comparability of standards for qualifications at all levels.

Guidance and exemplification of teaching and learning about the world of work is being developed, to illustrate the role, relevance and importance of vocational qualifications for pupils up to year 9.

The new Applied Science GCSE will be introduced in September 2002. This new GCSE will be of the same standard and intellectual rigour as existing GCSEs, but with a strong vocational focus. Early informal indications are that this new qualification will prove popular in schools.

QCA are undertaking further work with the awarding bodies to revise the AVCE in science into the AS/A2 format.

Universities' demands

23. **Where universities place restrictive demands on applicants, specifying grades in three A level subjects, students are unlikely to place value on broadening their education.**

Institutions delivering higher education will assess whether a candidate is suitable for entry to a course. Although A levels remain vital qualifications and an important way of assessing university access, universities have always sought to consider other measures of potential including the personal statement of the applicant themselves. However, it is for each university to decide its own approach, we are not empowered to direct universities in admissions procedures as they are autonomous bodies and are responsible for their own decision making processes.

See also response to recommendation 54.

Responsibility

24. **We are amazed that the awarding bodies take so little responsibility for finding solutions to problems with GCSE science that they themselves have caused. We take little comfort from their ability to identify these problems when they show little initiative in addressing them. Government should make plain to the awarding bodies that the future accreditation of their science GCSE courses depends on them developing imaginative alternative ways of assessing science at GCSE. Any changes to the National Curriculum will have limited impact on the way science is taught in schools if the assessment is not changed too.**

25. **QCA's lack of direction has allowed assessment of GCSE science to stagnate. QCA should now set out clearly what they expect of awarding bodies offering science GCSEs and should intervene where these criteria are not met.**

26. **QCA should require awarding bodies to introduce a wider range of questions to GCSE science exams. These should enable issues raised by contemporary science to be used as the focus for questions; allow flexibility for students in their answers; and, most importantly, they should test a wider range of skills than the mere recall of facts.**

Response to recommendations 24 - 26

There are significant, and necessary, constraints on introducing rapid changes to the system. The evidence supplied by QCA summarised the requirements of an assessment system: assessment arrangements must be fit for purpose and outcomes need to be valid, reliable and manageable if they are to support learning programmes.

Confidence in assessment and qualifications systems relies heavily on the maintenance of standards. This is a major aspect of QCA's work. The Authority's science team contributes to the monitoring of national curriculum assessment arrangements and all accredited science qualifications to help safeguard validity, reliability, comparability of standards and fairness across the field.

QCA's submission to the committee also referred to evidence from regular scrutiny and monitoring programmes, which have highlighted a number of issues. These include: the possible distortion of learning programmes by an over-concentration on the external assessment; the implications for validity, manageability and reliability of internal assessment; the amount of time required for assessment; and, examination timetabling problems, notably for practical assessments in science.

Current developments are designed to address these issues, for example, in the changes introduced in September 2001 there is an increase in the range of questioning. (This is reported favourably in para 75 of the report). QCA's monitoring programme will ensure that these revised criteria are met by the awarding bodies (recommendation 26).

It is acknowledged that this is a relatively small change, which reflected the overriding need at that time, to ensure that the system remained robust and manageable. However, further changes are being introduced in September 2002 (GCSE Applied Science) and September 2003 (Pilot GCSE sciences).

Coursework

27. **We think that it remains important to assess practical skills at GCSE through coursework. But there is no point in continuing with coursework arrangements that have little educational value.**

28. **Coursework in science at GCSE needs a radical rethink. This is the responsibility of the awarding bodies but it is obvious that they are going to need significant encouragement from QCA. QCA should evaluate the coursework submitted in 2003, which will be the first to be submitted under the recently modified arrangements. If there is no significant change in the approach to investigative work, they should enter into immediate discussions with teachers and awarding bodies about how coursework could be changed to encourage more stimulating and engaging practical work in schools. In addition, we would like to see project work available to teachers as an option for GCSE coursework. This may mean reducing QCA's requirement that 20% of GCSE assessment be based on investigative skills measured through coursework.**

Response to recommendations 9, 27 and 28

We agree with the report in its recognition that the assessment of practical and associated skills, and the understanding of investigative science in its broadest sense, is an essential component of GCSE science, which must not be marginalized.

Coursework is crucial to assessing this aspect of science; it cannot be done satisfactorily through external examinations alone.

Current requirements leave the choice of content for coursework to the teachers and students, so it is possible to engage in the kind of open-ended investigations quoted with approval in paragraph 78. Despite this, the report has confirmed QCA's monitoring findings – that such opportunities are rarely taken up as the majority of teachers usually rely on a small number of activities, which they repeat with all GCSE classes.

The report acknowledges that it is too early to see if recent changes to the coursework requirements will make a difference, and recommends that QCA take action following the completion of the first GCSE courses in summer 2003. QCA is already planning a programme to review current coursework practice, with the awarding bodies, particularly aimed at disseminating good practice, for example in the integration of the work into the normal teaching of the subject, the management of the teaching of component skills of investigating and in the choice of a wider range of topics and contexts.

In addition, several other developments, designed to address these issues, are planned. The GCSE Applied Science takes a very different approach to coursework assessment as it is embedded throughout the course.

The pilot GCSE science will be trying out a range of different criteria for coursework assessment, in its different strands. For example, the core course will assess topical issues through written project work, whilst the additional applied course will ask for accounts of the applications of science in specific local contexts, as well as assessing practical procedures. This work is intended to find out ways of ensuring that coursework provides both valid assessment and a worthwhile learning experiences.

The problems to be solved are not trivial. Any nationally approved assessment system has to be robust enough to demonstrate that standards are upheld in the fair awarding of grades.

Science for citizens and for scientists

29. **We are convinced that science is essential for progression and for personal development and welcome DfES's decision to keep science as a compulsory element of the curriculum from ages 14 to 16.**

We welcome the committee's agreement that science should remain a compulsory element of the Key Stage 4 curriculum. The Green Paper, *14 - 19: extending opportunities, raising standards* noted the importance of science for the economy and for careers in many areas which increasingly need an underpinning of science. It recognised the need to ensure that science GCSE provides a range of choices relevant to all abilities and aptitudes.

30. **The challenge at 14 to16 is to provide a secure foundation for those moving on to further scientific study post-16 and to give an understanding of science to those who do not; that is, to meet the needs of future scientists and of citizens.**

See response to recommendation 39.

31. **Having taken the decision to keep science compulsory to age 16, DfES should include science in the requirements for any matriculation diploma.**

The Matriculation Diploma proposed a threshold of level 2 attainment in literacy, numeracy and ICT, because we think it important for as many young people as possible to reach this level. For science, we are seeking to ensure that all young people include this subject as part of their programmes of study until the end of Key Stage 4. However, we did not think that young people should be required to reach level 2 in science in order to gain the Diploma.

Ministers are carefully considering the views expressed about the Diploma proposal during the consultation period.

32. **What is important is not that citizens should be able to remember and recall solely a large body of scientific facts, but that they should understand how science works and how it is based on the analysis and interpretation of evidence. Crucially, citizens should be able to use their understanding of science, so that science can help rather than scare them.**

See response to recommendation 39.

33. **On balance we believe that the advantages of increasing the priority given to the teaching of skills associated with scientific literacy at GCSE far outweigh the disadvantages.**

34. **It is important that students are able to follow GCSE courses that fully prepare them to continue with the academic study of science at A level.**

35. **We commend QCA for taking the initiative in piloting a new approach to GCSE science which aims to reconcile the need to prepare some students for further study and to give all students the skills of scientific literacy.**

Response to recommendations 33-35

QCA's pilot GCSE, commended in the report for its new approach to GCSE science, will be introduced in September 2003. The lessons learnt from the evaluation of the pilot will be put into practice across all existing science GCSEs, as and when appropriate, furthering the aims for students aged 14 - 19 detailed in the recent Green Paper *14 - 19: extending opportunities, raising standards*. The pilot will provide useful evidence for other future GCSE developments, including possible hybrid qualifications.

A new curriculum

36. **We support the balanced science approach and believe that it should continue to apply for all students. However, within this, there needs to be flexibility and scope for choice by individual students to allow them to explore areas of interest.**

37. **All students should continue to spend 20% of their time studying science. At the same time, the National Curriculum at key stage 4 must be restructured to allow the development of a range of different science GCSE courses. This should enable students to choose courses that complement their abilities and interests in science. All GCSE courses should prepare students to feel confident with the science that they are likely to encounter in everyday life and provide a route to science post-16, either through traditional A levels or through vocational qualifications.**

38. **QCA should work together with stakeholders, including learned societies, teachers and students, to agree a National Curriculum that defines a minimum core of science that all students need to be taught at 14 to 16. This should include some of the key ideas in science across biology, chemistry and physics and a range of skills and understanding associated with scientific literacy. All qualifications in science offered at key stage 4 should then fulfil these revised National Curriculum requirements.**

39. **A new science curriculum will need to define more explicitly the skills and knowledge associated with scientific literacy.**

Response to recommendations 30, 32, 36 - 39 and 43

Balanced Science

We welcome the Committee's support for balanced science in the National Curriculum. Our recent consultation on 14 - 19 education explored the options for more flexibility and choice post 14, and offering different learning pathways to suit the needs and aspirations of individuals. We are already putting in place new qualifications, for example, the GCSE in Applied Science. In our development of the new pilot science GCSE we shall be focusing strongly on the options this approach will open up post 16, the need for the qualification to offer flexible pathways, both vocational and academic, to lay a secure base for further scientific study for those who choose to do it and to provide all young people with a sound grounding for adult life and their role as citizens.

Time for Science

The Government accepts that schools need to provide sufficient time within the timetable to allow the study of all subjects, including science, within a broad and balanced curriculum. However, there is no minimum time prescribed for the teaching of any subject at any key stage, although there is timetabling guidance available for schools.

For science, the statutory requirement is the single award programme of study. However we expect that double science or the three separate sciences will continue to be taken by the great majority of pupils. It is also important to note that within existing National Curriculum requirements, science can be disapplied altogether for students undertaking an extended work-related programme. For the majority of pupils however, science will continue to need a significant portion of curriculum time.

Reviewing the science curriculum

The Qualifications and Curriculum Authority (QCA) is to advise the Government on restructuring the curriculum at Key Stage 4 as part of the 14 - 19 reforms, including science. QCA is already undertaking a review of science, Science for the 21st Century, begun in 2000 as a follow on from the review of the whole curriculum. The new pilot GCSE has come from this review. We will ensure, both through the development of the new pilot and through the wider reforms, that science is developed to offer wider opportunities for young people. As we set out in our 14 - 19 consultation, we will carefully consider reducing the content of the science curriculum at Key Stage 4 to provide a smaller compulsory core relevant to all learners. The Government agrees that scientific literacy, sometimes also referred to as 'science for citizenship' is an important area for development.

Citizenship

To teach Citizenship well, we need to engage pupils in appreciating how advances in science can affect them as individuals, and as part of a community. They will need to understand the types of question that science can answer and the ones it cannot. As citizens they will need to reach their own views about the ethical, political and economic questions that science cannot answer.

The schemes of work for secondary schools include example units within which schools teach citizenship through science and vice versa. The structure and activities suggested are designed so that they might be applied to any contemporary science-related issue, typically on a national scale. As an example, immunisation is used throughout the unit. Other issues, e.g. food safety, organ donation and transplants, forensic science, could provide an alternative focus. The emphasis is for pupils to consider a range of points of view; to explore the conflicting rights and responsibilities involved, such as those of individuals and the interests of the wider public. They learn that views may conflict and that expert opinion cannot always arbitrate between them.

Assessment

40. **Incorporating scientific literacy in the National Curriculum will not, on its own, be enough. If this aspect of the curriculum is to receive the attention that it deserves it must be given a higher priority in assessment.**

41. **Research and development needs to be undertaken to develop ways of assessing the skills associated with scientific literacy. This should be seen as an urgent priority and funded by Government.**

Response to recommendations 40 and 41

The report recognises the possible problems associated with this in paragraph 88. As the report notes in paragraphs 101 and 102, there has been an increase in the extent of the assessment of aspects of 'Scientific literacy' in the current specifications, following the 2000 revision of the science National Curriculum. QCA's monitoring shows that many teachers are not finding it easy to implement and that they need professional development to support them (this is consistent with the Wellcome Trust report *Valuable Lessons*). QCA already has a long-term research programme into developing assessment methods and approaches generally (both formative and summative). As part of the curriculum development project 'Keeping science into step with the changing world of the 21st century', QCA has commissioned work on the nature and the assessment of 'scientific literacy'. The findings from this research have already informed developments at KS2 and 3 and are feeding into the development of the pilot science GCSE. (The implications of this, particularly at GCSE, are substantial – involving coursework issues discussed earlier.)

Support for teachers

42. **If science teachers are to be asked to teach a different curriculum at key stage 4, they will need time, resources and training. The Government must ensure that all three of these are available to teachers before implementing any major changes in science at key stage 4.**

We recognise the implications for teachers of curriculum change and the need for time, resources and training.

The Government has demonstrated already its commitment to raising standards in the middle years by supporting expenditure of around £500 million on Key Stage 3 over three years to 2003-04. This covers teachers access to training programmes, consultancy support and money for schools to focus on pupils who need extra support. The National Centre for Excellence in Science Teaching will offer training for all teachers of science, primary as well as secondary. Provision will be designed to meet national priority needs in science education, as well as being sufficiently flexible to respond to those of a more regional/local nature. Changes to the curriculum would be high among national CPD priorities for science teachers.

Diversity

43. **QCA should work together with the awarding bodies to develop a range of courses in science at key stage 4 that reflect the diverse interests and motivations of students.**

See response to recommendation 39.

44. **The evidence from A level courses that focus on presenting science in contemporary and relevant contexts suggests that it is possible to attract girls to study physics and for them to enjoy the experience. This has lessons for the study of physics at 14 to 16. QCA should explore how the curriculum and assessment at key stage 4 could be adapted to reflect the positive features seen in the new physics A level courses.**

The new science GCSE, which QCA has commissioned OCR to develop, utilises many of the approaches employed successfully by A level courses to attract girls to study the physical sciences. This includes greater emphasis on the human implications of the science content and an increased range of coursework tasks in the assessment framework.

45. **We recommend that the Government consider how best to ensure the future of the Ishango after-school Science Clubs, if necessary by continued central government funding.**

The DfES recognises the positive contribution that out of school hours educational initiatives can make to the achievement and aspirations of ethnic minority pupils. Ishango Science Clubs are part of an estimated 2,000 or more community based organisations offering a range of after school educational support to pupils from minority ethnic communities. These initiatives are often called supplementary schools or Saturday schools.

Through the Extended Schools and Study Support programme the Department is encouraging out of school hours activities and greater use of mainstream schools as a community resource. As part of a wider strategy to raise the educational attainment of ethnic minority pupils, Ministers are considering how best to promote greater partnership working between mainstream provision and the great variety of community inspired education initiatives such as the Ishango Science Clubs.

46. **The African-Caribbean Network for Science & Technology recommends that the Government commission further research on race equality in science, maths and technology and explore ways of targeting resources on underachieving groups. It calls for science teaching materials to be developed to encourage multi-cultural and anti-racist teaching; and for teacher training and continuous professional**

development for science teachers to include these elements. We endorse these recommendations.

At Key Stage 3, the *Framework for teaching science: Years 7, 8 and 9* includes a dedicated chapter on "Inclusion and differentiation". This chapter covers the needs of pupils who might need extra help in science lessons: those who need help with English (including those learning English as an additional language); those with special educational needs; disabilities; emotional and behavioural difficulties; as well as able pupils and those who are gifted and talented.

Through the Key Stage 3 Strategy, support has been provided for mentoring under-achieving pupils in science in year 8, and supporting borderline pupils in achieving level 5 or above in the tests in year 9 through the booster programme. Generic materials are also being developed through the Key Stage 3 Strategy, which focus on teaching and learning for specific groups, including those from ethnic minorities.

In our response to the Roberts review we acknowledged the importance of encouraging ethnic minority pupils to achieve more and to participate more widely in science. We are committed to working with key partners, such as the Commission for Racial Equality and representatives from community groups – to develop a coherent strategy for raising the achievement of ethnic minority pupils. The Roberts review specifically recommended the Government improve the data available on the achievement of ethnic minority groups in science and engineering and we have accepted this recommendation.

One of the aims of Science Year has been to improve the perception of science among 10 - 19 year olds, with particular emphasis on girls and ethnic groups. Poster campaigns such as "Faces of Modern Science", have used role models from different backgrounds in science related careers, to show how studying science can lead to exciting and lucrative careers for all students regardless of their background. Science Year is also working with Black Parents in Education to create a website celebrating the achievements of black scientists past and present. The extension of Science Year will place additional emphasis on bridging the attainment gaps between different ethnic minority groups.

The continuing expansion of the Science and Engineering Ambassadors scheme also has great potential to influence young people from ethnic minority groups through the recruitment of role models from those groups to work with young people in schools.

Through the National Centre of Excellence in Science Teaching, we will encourage teachers to adapt their teaching approaches to meet the needs of all pupils, including those from ethnic minority groups, young people of both sexes and those with special needs.

Specialist schools

47. **We welcome the establishment of science and engineering specialist schools as a recognition that Technology Colleges, although numerous, are not representing the breadth of science and technology education. The Government should set a target for the number of science and engineering specialist schools within the overall target of 1,500 specialist schools by 2005.**

We do not want to prescribe a uniform pattern of specialist provision. As part of the Government's wider strategy for sport in schools, we have a target for the number of Sports Colleges. This is linked to the School Sport Co-ordinator programme and to the promise set out in the White Paper Schools achieving success, of an entitlement of two hours of high quality PE and sport each week in and out of school for all children. We also have a target for Language Colleges in connection with the developing national languages strategy.

Beyond that, we do not at present see the need for firm targets in the other specialist areas. Our aim is to help secondary schools and local education authorities to develop a strategic pattern of specialist provision in order to best meet local needs and maximise the benefits of the Specialist Schools Programme for local communities.

48. **We urge scientific bodies to consider how they can encourage and support schools to apply for science specialist status.**

We would welcome the involvement of scientific bodies in supporting schools interested in applying for designation as Science Colleges.

49. **In providing A level science courses it is difficult to strike a balance between attracting a broad range of students and providing the content needed for transition to science-based courses at university. The onus should be on universities to adapt to the changing nature of their intake. The Roberts Review recommends that the Government fund universities to use new "entry support courses" and e-learning programmes to bridge gaps between A levels and degree courses. We endorse this recommendation.**

The Government agrees with the Committee's analysis – responsibility for designing and delivering degree courses lies with higher education institutions, and it is ultimately for individual institutions to make sure that they teach students what they need to know in order to progress in science, engineering and mathematics courses. However, on some courses students can have quite a range of previous experience in maths and science – some with relevant A levels, some with access course experience, some with GCSE level maths. Many non-traditional students in particular need extra support in technical skills. Institutions already put a good deal of effort into supporting new students, bringing them up to speed, and providing on-going specialist support with important underpinning skills.

In response to the Roberts Review recommendation, the Government has announced that it will work with the HE sector to pilot and evaluate different approaches to bridging the gap between students' prior knowledge and the requirements of higher education study, recognising that Mathematics skills can be a particular issue. The Government is also launching a specific inquiry into post-14 mathematics.

50. **On balance we are persuaded that the mathematical demands of school science at A level are appropriate. Where students need support with their maths, additional maths courses are available for schools to offer. Any increase in the maths content of A level science courses would risk alienating students further. Where universities require greater mathematical skills, they should take action to teach these themselves.**

Response to recommendations 20 and 50

The Government agrees that there is a fine balance to be struck in the mathematical content of science subjects – between making A level science subjects too mathematical and so deterring some students, and not including enough maths to be able to cover the subject properly and lay appropriate foundations for HE. Physics is the most mathematical of the sciences and these subjects have long enjoyed a close relationship.

Schools need to make sure they provide adequate mathematics provision to support the teaching of sciences, such as the weekly mathematics lessons described by Claire Dawe at Redland High School in Bristol. The Curriculum 2000 reforms have broadened the range of mathematics qualifications available. In addition to A level maths, students can now

take maths just up to AS level, the new AS in Use of Mathematics, or Free Standing Mathematical Units. These provide students with opportunities to take maths courses that best meet their individual needs.

It is also the responsibility of higher education institutions to provide appropriate support to ensure all their students can develop the mathematical skills require for their courses (see comments in response to recommendation 49).

51. **The Government should ask QCA and the awarding bodies to explore how it would be possible to address the imbalance in grading across A level subjects.**

See response to recommendation 19.

Vocational alternatives

52. **FE colleges offer a range of science-based vocational courses linked to specific careers. These give students the opportunity to engage with science and achieve where they may previously have struggled.**

FE colleges and their vocational courses have an important contribution to make. In the academic year 2000/2001 1.9 million science courses were being studied in FE institutions.

53. **For those students who do not achieve Grade C in GCSE science, there need to be intermediate qualifications available that will allow them to move on to AS and A level.**

Ministers have listened carefully to the representations from colleges. They have decided to retain the 6 unit Intermediate GNVQs until QCA can establish that there are suitable alternative vocational options available in each of the subject titles.

QCA has been asked to publicise this decision and respond to any detailed enquiries about the work to identify or develop future provision.

Science for all

54. **In evaluating the new AS and A level structure, the Government should look closely at whether the changes have successfully broadened the curriculum studied by post-16 students. If this is not the case, Government should consider the introduction of a compulsory post-16 curriculum, which would include science as one of its core subjects.**

Early monitoring and research have suggested that while students are generally taking larger programmes, they tend to take complementary rather than contrasting subjects. Schools and colleges encourage students to consider broad programmes and provide a curriculum structure to facilitate them, but few insist on specified breadth.

The DfES and QCA will be evaluating the extent to which the changes to advanced level qualifications have achieved their stated aims, including increasing the breadth of student programmes.

55. **Improving the experience of science at 14 to 16 in the ways that we suggest in this report should motivate students to consider studying science post-16. They should be**

provided with proper careers advice. Government should ensure that the careers service improves the quality of advice offered to school students about scientific careers and the breadth of career possibilities open to those with qualifications in science.

The Connexions Service offers impartial advice and guidance on learning and career options to all young people aged 13-19 in England. Its starting point is the interests and aspirations of the individual young person and it does not seek to actively promote any one career/occupational sector over another. However, where young people express an interest in science-related further learning or careers, Connexions Personal Advisers will offer guidance and support as necessary. This is supported through a range of mechanisms:

- The Connexions Service National Unit (CSNU) produces a range of publications aimed at practitioners working within the Connexions Service and young people and their parents. For example, for the former, *Occupations*, which is updated annually, provides information for Connexions Pas on a wide range of science-related occupations. There is also a series of *Working In* publications for young people/parents, one of which is *Working in Science*. These are updated periodically, on a rolling programme, in liaison with the relevant NTO/SSC.

- Most Connexions partnerships have dedicated "information managers" who are responsible for collecting and disseminating Labour Market Information to practitioners. This will include information on developments within the science-related occupations/sectors.

- CSNU has worked closely with DTI to support initiatives such as Science Year through, for example, articles in a variety of Connexions newsletters/publications.

- Connexions also works more generally with all young people to raise their aspirations and to ensure that the choices they make in Key Stage 4 and post-16 learning will support progression into science-related careers, where this is what individual young people aspire to.

The Roberts review also raised a similar point and, as recommended by the review, the Government is establishing a team that can help Connexions personal advisers and teachers in offering careers advice. In doing so, the Government will draw upon the expertise of those in the scientific, engineering, technological and mathematical communities. The Government will consult with the Sector Skills Councils and Connexions Service National Unit to establish whether this team is best based within the Connexions service or in the relevant Sector Skills Councils but closely linked to the Connexions Service.

56. **We welcome the motivation behind the Government's Science and Engineering Ambassadors initiative and look forward to seeing an evaluation of how effectively it is implemented and what impact it has.**

We welcome the Committee's support for Science and Engineering Ambassadors. SETNET, which manages the scheme on behalf of the Department for Trade and Industry and the Department for Education and Skills, has recently appointed a national Ambassadors manager, the SETPoints who deliver the scheme locally are working to sign up companies in their areas and there are also eleven large companies signed up UK wide. We accept Ambassadors should be evaluated and, an evaluation of SETNET, which includes Ambassadors, is in its early stages. In our response to the Roberts review, we have also said that we will continue to ensure that SETNET has clear measures of success and that the network of SETPoints will be evaluated.

57. **A benefit of requiring science to be taught using contemporary contexts is that it would encourage more science teachers to make use of local science based employers to support their teaching.**

The development of coursework requiring projects focussing on modern applications of science is a useful way of creating more links between schools and local businesses.

Laboratories

58. **Good laboratory and prep room facilities are important because they enable high quality practical work to be carried out in a pleasant environment, motivating and inspiring staff and students alike.**

59. **It is appalling that the laboratories in one quarter of England's secondary schools are in such poor state that the quality of teaching is being directly affected.**

Response to recommendations 58 and 59

The Government agrees that good laboratory and prep room facilities are important to enable high quality practical work to be carried out. It is not acceptable for the quality of teaching to be affected by the poor state of school laboratories. It has increased capital investment in schools, including in school laboratories, from £683 million in 1996-97 to over £3.5 billion in 2003-04, and this will rise further by 2005-06. In particular, the government allocated £60 million to local education authorities to fund improvement in laboratory provision in 2000-01 and 2001-02, to highlight the need and to address the worst of the backlog. Most recently, it has put improvement to science and technology facilities as a key priority for local authorities in prioritising their school investment. The current appraisal of local authority Asset Management Plans includes close scrutiny of their plans for improvements to school science laboratories.

60. **We welcome the £60 million committed to laboratory refurbishment by DfES; this should have made a significant impact. We are very surprised that DfES has not evaluated what impact this substantial sum of public money has had on those schools most in need.**

The bulk of capital funding for school buildings is now allocated by formulae with needs related elements. This increases local decision-making and avoids the heavy bureaucracy inherent in bidding processes. To reduce the bureaucratic burden further, DfES has not required details of local investment decisions. The £60 million for laboratory refurbishment was ring-fenced for that purpose, and guidance emphasised that the investment was for schools with the most serious suitability shortcomings in their science accommodation. Investment decisions were taken locally by education authorities and schools as to where the greatest benefits would be. However, we also appraise the local delivery of improvements to school buildings, including laboratories, through the Asset Management Plan process. Asset Management Plan data collection in the first part of 2003-04 will include assessments of the needs of science teaching spaces.

61. **We recommend that, over the next three years, the Government ring fence a minimum of £120 million to bring all school laboratories and prep rooms up to at least adequate standard. This money should be allocated direct to LEAs so that it can be targeted at those schools most in need.**

The Government aims to reduce the amount of funding that is ring-fenced. Small ring-fenced pots are particularly bureaucratic to administer, and can have perverse consequences in restricting investment in needs only to the amount of funding allocated. From 2003-04 until 2005-06, the Government will further increase the capital available for investment in school buildings. As far as possible, this funding will be delivered to schools and local education authorities by formula with three-year certainty. Asset Management Plans are now established so that authorities can prioritise the investment needs of all their schools in an open and consultative process that takes account of local circumstances and government priorities. Through the criteria it sets, and the monitoring of Asset Management Plans, the government will continue to ensure that Local Education Authorities prioritise improving science provision in their schools.

In addition to the capital funding the Government allocates to local authorities, it also gives all maintained schools their own capital money. In 2003-04, a typical secondary school will receive New Deal for Schools Devolved formula capital of over £70,000. This funding can be rolled over for up to three years and every secondary school now receives direct capital funding which enables it to address the needs of its science accommodation.

62. **DfES should ensure that schools are properly informed of the importance and costs of maintaining expenditure on science equipment.**

We are working with key partners, including Science Year, to explore how the whole issue of laboratories and equipment fit for the 21st century can be highlighted and guidance given to schools. The Department already produces extensive technical guidance on the design of school buildings including science laboratories. We have also included science and design and technology laboratories as priorities in this year's capital expenditure guidance to Local Education Authorities. However, we think more could be done to support schools to design and manage laboratories and to purchase and maintain equipment. With new developments in science, different equipment might be needed. Increased use of ICT and different approaches to teaching may both require a new look for laboratories, for example, including bigger discussion and group working areas. We will be working with our partners to develop interactive, flexible and user-friendly resources for schools to help in assessing their needs and procuring the accommodation and equipment necessary to teach science in the classroom of the future.

Technicians

63. **We expect to see action taken within the next year to address the appalling pay and conditions of science technicians and to create a career structure that will attract skilled and dedicated people to work as technicians.**

64. **It is essential that technicians have opportunities for professional development. This will mean not only making appropriate courses available but also ensuring that technicians have the time and funding to be able to participate.**

See response to recommendation 66.

Practical work

65. **There is a widely held belief that practical work in schools is now constrained by health and safety regulations. This is simply not true.**

We welcome the Committee's emphasis on the lack of constraints on practical work in schools due to health and safety regulations and agree that the practice of risk assessments is likely to enable a wider range of experimental work to be carried out.

66. **The longer-term aim should be to reduce secondary school practical classes to no more than 20 students.**

Response to recommendations 63, 64 and 66

The Government believes that the best way of addressing the concerns underlying the Select Committee's recommendation is to enable teachers of secondary science to have more support from other trained and appropriately checked adults. The White Paper: *Schools: Achieving Success*, published in September 2001, recognised many teachers felt they had inadequate time in the normal working day to prepare lessons, review pupil progress or undertake professional development. That paper fed into *Professionalism and Trust* and set out the Government's vision for an education system in which learning is supported by a wider mix of well trained staff undertaking a range of duties and tasks, together with more effective use of ICT. While additional resources will be made available to schools for restructuring and to employ more support staff, the Government believes their precise deployment should be a matter for head teachers who are in the best position to assess needs at individual school level.

Our proposals to make greater use of support staff as direct assistants for teachers is particularly relevant to science technicians who could (and in some cases already do) assist with practical work. We will be formally consulting on our proposals for enhancing the roles of support staff in the autumn. We will invite comments on a range of proposals including enhanced roles and responsibilities for support staff, training and development, implications for school management and the need for guidance for schools and local education authorities. Links between potential roles and the pay of support staff, will, however, remain a matter for local determination.

We welcome the Royal Society/Association of Science Education report on science technicians and we are working with them to look at the recommendations in the report. We are exploring a career structure for technicians that links job descriptions, vocational qualifications and professional development. In our consultation on the National Centre for Excellence in Science Teaching, we proposed that Continuing Professional Development for science technicians should be included in its remit. This proposal was strongly endorsed by respondents and science technicians will have specific provision offered by the national centre and its regional arms. The Engineering Technology Board is considering how it can contribute in this area.

We envisage that Ambassadors will also assist in practical science classes, given appropriate checks, suitable personal skills, professional scientific expertise and appropriate coaching. An additional trained adult in the science laboratory would do much to allay health and safety concerns and give more time for the teacher to concentrate on teaching.

APPENDIX 2

RESPONSE OF THE QUALIFICATIONS AND CURRICULUM AUTHORITY

We share the enthusiasm for science displayed by the Committee and recognise the value of the evidence they have collected. The resulting insights will help QCA in its role of developing the science curriculum and its assessment and in supporting the provision of high quality qualifications in science. This response is concerned with the report's recommendations (Rx) which relate to QCA's work.

Science for 14 to 16 year-olds (Key stage 4)

The report expresses particular concern about the effect on students of the ways in which the GCSE science curriculum is currently taught and assessed (R1). The report identifies as the key challenge, the need to teach science successfully, both to those who will continue with science and to those who will stop at the end of this stage (R6, 30, 37). We are pleased therefore that QCA's initiative (Science for the Twenty first Century) is commended by the Committee (R35).

Science for the Twenty first Century Pilot and other GCSE developments

The pilot development and the new GCSE in Applied Science are intended to tackle exactly those issues and problems identified in the report. These include:

- *Students should understand how science works and how to use it (R32).* The specification of the pilot GCSE is based on criteria focused on 'ideas about science' which have precisely that aim. In the new GCSE in Applied Science qualification, students are required to apply the science they learn in a choice of work-related contexts.

- *Students should study controversial topical and ethical issues (R3&4).* Whilst recent changes to GCSE science courses have encouraged this, the GCSE pilot presents such opportunities in a prominent way, with key questions such as: 'What choices can we make ... that will make a difference to air quality? In what circumstances should cloning be allowed? Is it safe to use mobile phones?'

- *All students should develop their scientific literacy skills (R33,35,39) and the assessment system needs to be developed to encourage this* (R40,41). The project has commissioned work on how the concept of scientific literacy should inform the science curriculum at key stage 4 and its assessment. This work has been used in the development of the GCSE pilot, and is reflected in the rationale, the content and the assessment scheme for this qualification. It should be noted however that in the recent PISA international comparison (1) of achievement in scientific literacy, English students were placed fourth in the ranking of 27 countries.

- *All students should be entitled to study GCSE courses which fully prepare them for science to 'A' level (R34). The balanced science approach should continue for all, but there should be more flexibility and choice for individual students (R36).* In both the GCSE in Applied Science and the pilot GCSE qualifications, students are required to cover a balanced range of science which will prepare them for advanced GCE or VCE study, and offer a range of choices which have not been available previously.

- *Key stage 4 courses should be developed which reflect the diverse interests and motivations of students (R43).* The pilot GCSE incorporates choice both at the level of a whole course (more or less applied) and within the applied course, with a free choice of the three modules to be studied.

- *Key stage 4 courses should be developed using the experience of recent AS/A developments which encourage girls to be interested in physics (R44).* The development of the pilot GCSE has been shaped by the experience of an AS course in Science for Public Understanding, which has attracted girls to study physics post-16.

- *Teaching resources should be developed which encourage multicultural and anti-racist teaching (R46).* The evidence from the African-Caribbean Network for Science and Technology, on whose work this recommendation is based, has shown the importance of suitable role models to inspire pupils from ethnic minorities to succeed and to continue to study science. The pilot GCSE teaching materials are expected to feature such role models in support of the aim of showing how science works. QCA has collected examples of diverse and inclusive practice, which will be disseminated through our websites to encourage participation in science by young people from all cultural groups.

National Curriculum

The Committee's proposal for a revision of the National Curriculum requirements for 14 to 16 year-olds *(R38)* has been anticipated by the DfES in its consultation on the 14 - 19 curriculum. QCA expects to be offering advice to the DfES on the need for, and nature of, any changes, and will be using evidence from the evaluation of the pilot GCSE and the new GCSE in Applied Science, as well as our monitoring evidence of current practice in GCSE science.

Teacher support

We are in full agreement with the Committee's view that there is a need for teacher support to enable changes to be successfully brought about *(R42)*. QCA can provide authoritative guidance and exemplar materials. Wide support for the pilot GCSE has resulted in substantial funding from charitable trusts for the development of teacher support and learning resources. We are providing advice and support to this work. We are also involved in the DfES teacher support projects including Planet Science (formerly Science Year), the key stage 3 science strategy and the plans for a national centre for excellence in science teaching.

Assessment including coursework

We regard as unwarranted the strong criticism of the awarding bodies' performance in relation to GCSE assessment *(R24)*, and of QCA for not changing this *(R25, 26)*. Assessment has developed in response to the changing curriculum, for example, the criteria for assessing scientific enquiry were updated in September 2001, to reflect changes in the National Curriculum. However, it is equally important to safeguard standards and protect candidates' interests by moving forward at a pace which will allow all concerned, particularly teachers, to implement changes with confidence.

We agree with the Committee's conclusion that practical work is an essential part of any science study but can find no justification in the report, or in our own extensive evidence, for the blanket condemnation of coursework assessment *(R27)*.

We believe coursework to be essential to the valid assessment of practical aspects of science. Current requirements leave the choice of content for coursework to the teachers and students, so it is quite possible to engage in the kind of open-ended investigations quoted with approval in paragraph 78. The report confirms QCA's monitoring findings that such opportunities are rarely taken up. Many teachers seem to rely on a relatively small range of assessment activities.

The report acknowledges that it is too early to see if recent changes to the coursework requirements will make a difference, and recommends that QCA takes action following the completion of the first revised GCSE courses in summer 2003 *(R28)*. We support this view and are already planning to review current coursework practice with the awarding bodies. A key aim will be to identify and disseminate good practice in, for example, the integration of the work into the normal teaching of the subject, the management of the teaching of component skills of investigating and the choice of a wider range of topics and contexts.

GCSE in Applied Science takes a very different approach to coursework assessment which is embedded throughout the course. The pilot GCSE science will use a range of different criteria for coursework assessment in its different strands. The core course, for example, will assess topical issues through written project work, whilst the applied course will focus on the applications of science in specific local contexts and assessing practical procedures.

Science for 16 to 19 year-olds

Attitudes to science

The Committee's enthusiasm for science is evident in their wish for as many students as possible to choose science post-16. We support that objective but consider that some of the recommendations may be less helpful than intended. To state baldly it would seem that students study science post-16 not because of GCSE science but despite it *(R12)* is inconsistent with evidence in the report and elsewhere. In reality:

- Science subjects are popular at A level. 60% of candidates enter at least one science or maths A level *(paragraph 46 of the report)*.

- Ofsted reports that 'standards of achievement have continued to rise slowly overall' and 'In over six out of ten schools the teaching of science is good overall' *(secondary subject reports 2000/01, HMI 2002)*.

- International comparisons have shown that English students' performance is higher than that in most other countries (*TIMMS 1999 for 13/4 year-olds and PISA 2000 for 15/16 year-olds*).

- Research shows that students often reflect the common attitudes of the general public, that science, though difficult, is important. A recent study of pupils and their parents concluded: 'All pupils and their parents considered science to be an important subject of study and that it has a legitimate place in the curriculum. Science was seen as a prestigious subject and valued for the understanding it offered of the natural world'. The common ambivalence was, said the report, well expressed by the following pupil quote: 'I think we all have this view of science being boring, but if you sit down and speak about it you realise it is actually important. It is actually relevant to the things you've got to do.' *(Pupils' and parents' views of the school science curriculum, Osborne and Collins, King's College, London 2000)*.

- Pupils' attitude to their own learning in science was explored in the TIMMS 1999 study of 13/4 year olds. English pupils displayed more positive attitudes to their own ability in science than most other countries in the study.

Take-up of the sciences

The Committee expresses a view *that recent reforms to post-16 education have not produced significant increase in the number of students studying the sciences (R13).* Yet, as the Committee recognises, it is too early in the life of the new AS/A system to draw firm conclusions. The 2002 results give some grounds for optimism. In 2002, the proportions of the cohort taking biology and physics showed a significant increase for both boys and girls. In chemistry, the total number of girls exceeded that of boys for the first time, but the total proportion of the cohort has remained unchanged for the past four years.

Inter-subject comparisons

The report expresses concern that students may be dissuaded from continuing with science at A level because they think that it is more difficult to achieve a higher grade in science than in other subjects *(R19)* and recommends that *the Government should ask QCA and the awarding bodies to explore how it would be possible to address the imbalance in grading across A level subjects (R51).*

The Dearing Report of 1998 included considerable work in inter-subject comparability. The report recognised the complexity of the issue and concluded that crude adjustments can do more harm than good. Nevertheless QCA remains concerned and we will continue to monitor awarding body performance in this area. We are currently devising an additional programme of work in response to the recommendations of the independent panel report on maintaining A level standards (the Baker report), which also discussed these issues. QCA has recently piloted new methodologies for analysing inter-subject comparability. Initial outcomes have been promising and we will continue to work with subject specialists, assessment researchers and advisory bodies to ensure that AS/A level sciences develop in a way that is attractive to students and credible to users in higher education and employment.

APPENDIX 3

RESPONSE OF THE JOINT COUNCIL FOR GENERAL QUALIFICATIONS

The Joint Council is pleased to receive this report, taking an overview of Science Education 14 - 19. The Joint Council would endorse many of the individual points made in the Report and particularly those relating to the need for a review of the National Curriculum requirements and range of GCSE courses available to centres and students. A GCSE specification, however good it may be, cannot itself motivate students. There are many inter-related reasons why students might not enjoy and continue with studies in science subjects. The Joint Council would suggest that the professionalism and training of teachers, and techniques of teaching employed, have a far greater impact on whether students enjoy and engage with the subject. Likewise the level of support and working environment of the teachers impacts greatly on their ability to produce motivating and stimulating lessons, etc.

It is noted that the Report has been published before the first cohort of students have completed their studies and assessment based on the revised, 2003, GCSE specifications. There might usefully be a review of the recommendations made in this Report in the light of experience of the new specifications.

The Joint Council has also noted that the sample of teachers, students and users consulted was small.

The following specific comments are offered against the list of recommendations and conclusions given in the Report on pages 59-64.

The GCSE Curriculum

The Joint Council agrees that the current National Curriculum is overloaded and would support a reduced emphasis on content and an increased emphasis on principles, understanding and skills. A more open approach giving Awarding Bodies freedom to develop content which is relevant and interesting to students and to develop stimulating methods of assessment would be welcomed.

The Joint Council would support the introduction of recent scientific developments into the curriculum to make it more relevant to students' personal experiences and interests.

However, teachers report that relevant material is not necessarily interesting, stimulating or challenging. Students can be turned off science by endless discussions of pollution, global warming, ozone depletion, energy generation, topics in which teachers and students often lack sufficient knowledge and understanding to fully appreciate the problems involved. The need to ensure such issues are addressed in the teacher training process is paramount to ensuring their successful introduction into students' courses of study. Teachers constantly ask Awarding Bodies for more detailed schemes of work specifying what to teach and how it will be assessed.

Practical and Fieldwork
Coursework

The Joint Council supports the expansion of these hands-on learning opportunities and looks forward to changes in the relevant QCA Qualification and Subject Criteria for science that would permit these exercises to play a meaningful role in the assessment scheme of specifications. It is acknowledged that they can be adopted as an effective teaching strategy in the current specifications but more centres are likely to use them to greater effect if they are reflected in the assessment packages.

Whatever practical coursework is required, it must be practicable in schools which at Key Stage 4 often have many large groups of students.

Use of ICT

ICT will play an increasing role in the teaching and, ultimately, assessment, of many subjects. However, care must be taken to ensure that the relevant equipment, knowledge, experience and support mechanisms are in place in all centres to ensure that this does not become the province of the privileged few. Likewise, care must be taken to ensure that the teacher/student relationship and interface is enhanced and not undermined by the introduction of teaching, learning and skills development through the use of ICT.

Take-up post-16

The Joint Council believes that the introduction of the latest core curriculum has, in fact, served to increase the required factual content of A level courses. It has also to be acknowledged that the concerns about parity in demand between A level courses is an issue that has been raised by centres. Awarding Bodies' Research Departments routinely carry out research into the effectiveness of assessment schemes. Despite evidence to the contrary, the Joint Council is aware that the public perception persists that maths and science qualifications are 'harder' to succeed in than arts and humanities subjects and, consequently, would support the recommendation to investigate this issue further.

Gender and Ethnicity

Comments under 'The GCSE Curriculum' above refer.

Student perceptions

The essentially mathematical nature of Physics makes it at least desirable that potential students are reasonably competent in mathematics. To be allowed to select Physics without understanding its mathematical nature would be to mislead students. The reverse is also true. Able mathematicians might not be attracted to physics if its mathematical character and appeal was concealed or played down.

The most able students, those who, in earlier times, may have taken degrees in science or engineering, may now think in terms of 'how much will I earn' and apply for other degree courses. Concerns about the failure of students to be aware of scientific careers should perhaps be laid at the door of individual school or college careers departments – recommendation 55 in the Report reflects this fact.

The Joint Council would not agree, however, that students are unaware of transferable skills; there is ample evidence of science graduates becoming accountants and lawyers.

Vocational pathways

It is hoped that the introduction of new 'Applied GCSE' courses and the current development of new VCE qualifications to meet agreed Qualification and Subject Criteria (produced by QCA) will begin to make vocational courses more attractive to centres and students. An applied approach to science is not just about making the specification content more applied, it is also about the method of delivery, assessment and demonstrating the application of science. A more vocational approach makes it more interesting, dynamic, and is more inclusive for the type of learner who has a kinesthetic and visual learning style. This method of learning also encourages learners to take more responsibility for their own learning. A positive response to the introduction of these courses from employers and HE would help greatly in raising the profile of these qualifications.

Responsibility

There is some surprise at the recommendations and conclusions in this section. The constraints imposed by the National Curriculum requirements are acknowledged in the Report but no account appears to have been taken of the impact and constraints arising from the Qualification and Subject Criteria, developed by QCA, which all specifications must meet in order to achieve accreditation. Indeed, in vocational qualifications the mandatory units are prescribed by QCA and handed down to the awarding bodies.

Coursework/practical work used to play a much more prominent role in specifications in science and many other subjects. Constraints on the assessment weightings permitted for internally assessed work places, in turn, restrictions on the time available for it and the emphasis it is given in any course of study. Likewise, the weightings assigned to individual assessment objectives can dictate the range and type of questions employed to achieve effective and reliable assessment. Given the constraints imposed by the need to meet the requirements of the National Curriculum Programme of Study and the relevant Qualification and Subject Criteria, the Joint Council view is that the current GCSE examination papers contain a commendable range of question types, addressing a balance and range of knowledge and skills set in a range of application and issues-based contexts.

Whilst it is acknowledged that specifications can promote different teaching and learning strategies they can only do so to the extent that the 'rules they must obey' permit. It is interesting to note that the new developments welcomed in the Report do not necessarily conform to the current requirements and rules.

The Joint Council Awarding Bodies would welcome the opportunity to be actively involved in the review of the relevant Criteria and National Curriculum requirements.

Coursework

The comments under 'Responsibility' above refer. It is emphasised that, for any progress to be made, considerable changes to the National Curriculum Programme of Study and the QCA Criteria would be required. Indeed, the awarding bodies have, up to now, been praised by QCA for the way in which they work together to apply the Programme of Study.

Concern has been expressed that the QCA requirement for whole investigations in some subjects is the main factor holding back the development of more stimulating and engaging practical work. Many teachers and students find practical work, other than an investigation based on a 'plan', to be great fun and to have considerable educational value.

The Joint Council would like to see a wider debate on this issue.

Science for citizens and for scientists

The Joint Council would support the introduction of more modern scientific issues into the curriculum but would also draw attention to the need to ensure all students have a sound knowledge of the basics in order to fully appreciate, discuss and respond to issues in an informed manner.

Recommendation 34 is a key point which must not be lost in any reform.

A new curriculum

The Joint Council would support the suggestion that a greater range of science courses could be developed. The Awarding Bodies would welcome the opportunity to be involved in any review of the National Curriculum with a view to producing a core of study that promotes active learning that can be endorsed through the GCSE specifications developed.

Assessment

The need to have a clear and consistent understanding of what is meant and expected by the term 'scientific literacy' is crucial to the teaching and assessment of the skill. There is a real danger that teaching and questions based on Figure 5 (page 41) of the Report would be very demanding and stimulating to the most able students only.

Support for Teachers

The Joint Council would strongly endorse recommendation 42.

Diversity

As previously stated, the Joint Council would support the recommendation that a greater range of GCSE Science courses should be developed (comments under 'A New Curriculum' refer). However, it must also be recognised that there will be the need to ensure that comparability of demand is accurately monitored across the range of specifications in order that students, teachers and users of the qualifications can be confident of their 'worth'.

Specialist Schools

As a core subject it is hoped that all schools can be supported to develop sound, motivating and worthwhile courses in science.

A levels

The Joint Council would support the view that A level courses should be considered to be an end in themselves, educationally, as opposed to being designed primarily to meet the needs of universities

Vocational Alternatives

The principle that students must be provided with pathways that enable them to progress is one the Joint Council would support fully. This was the driving force behind the development of modular schemes of study and assessment (pre-Curriculum 2000) and why these courses became so popular. It is agreed that 're-sit courses' are rarely successful in motivating students and consideration should be given to how more stimulating options could be made available.

Science for all

The suggestion that a compulsory post-16 curriculum, that includes science as one of its core subjects, is something that could be counter productive and make science even more unpopular with students.

Laboratories
Technicians

The Joint Council believes that most science teachers would support these recommendations.

Practical Work

The Joint Council Awarding Bodies would agree with the conclusion in point 65 and would ask whether teacher training courses address this issue with NQTs and whether they have considered running refresher or INSET courses which could offer opportunities for teachers to be kept up to date with techniques, equipment and developments. The Joint Council believes that teachers would welcome practical science classes of no more than 20 students for GCSE courses of study. A smaller maximum number is desirable for AS, A level and Advanced Vocational courses.

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