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PRIMARY SCIENCE

Science became a compulsory subject in all state primary schools in England in 1989. There is general agreement that considerable progress has been made since then and government now views primary science education to be a success. There is also, however, concern outside government that advances made in the early years are in danger of being lost.

Issues discussed here include: how schools can both develop pupils' interest in science and prepare them for secondary school; the balance needed between teaching factual knowledge and the skills of scientific enquiry; the effects of the SATs tests; and the importance of teachers' scientific knowledge and confidence.

Background

The aims of primary science can be broadly divided into two categories:

- to stimulate pupils' curiosity in the world around them and encourage critical and creative thinking;
- to create a foundation for science at secondary school.

To fulfil these aims, pupils need to acquire both factual knowledge and the skills of scientific enquiry: identifying questions that can be addressed scientifically; planning and carrying out experiments; evaluating data; and recognising the limitations of their own and others' work.

The national curriculum

The national curriculum (NC) was introduced in 1989, with science as a core subject together with English and maths. Before 1989, the science curriculum varied widely between primary schools; the NC introduced a more uniform approach (see box opposite). The Qualifications and Curriculum Authority (QCA), an agency of the Department for Education and Skills (DfES), is responsible for the NC. Minor changes were made to the primary science curriculum when QCA revised the NC in 2000: a small reduction in factual content was balanced by an increased emphasis on scientific enquiry.

Primary science curriculum (ages 5 to 11 years)

Children learn about three areas of scientific knowledge:

- **Life processes and living things** – including human health and nutrition; plant nutrition; classification of animal and plants; the habitats of animal and plants.
- **Materials and their properties** – including how materials can be used; how they can change (burning, freezing, boiling); and how they can be mixed and separated.
- **Physical processes** – including electric circuits; forces; how light and sound travel; and astronomy.

Scientific enquiry

The areas of scientific knowledge are taught in tandem with the skills of scientific enquiry. Research suggests that good scientific enquiry should build on children's existing knowledge, interests and ideas; link to everyday contexts; and encourage discussion. Below is an example of the type of material that can be used to stimulate discussion.[1]

Source: Keogh and Naylor. See www.conceptcartoons.com

Guidelines for teaching the national curriculum

While the NC is statutory, schools have the freedom to decide how to teach its content to best meet the needs of their pupils. To help teachers plan their lessons, in 1998 QCA published non-statutory guidelines, known as schemes of work (SoW). These, for example, suggest classroom activities for teachers. Schools are expected to adapt QCA's SoW, or to devise their own, to reflect the interests of their pupils and the resources available in the local area.

Assessing pupils' performance

Pupils are assessed at ages 7 and 11 in English and maths through teacher assessment and national curriculum tests (widely known as SATs). Performance in science is determined by teacher assessment only at age 7 but teacher assessment and SATs at age 11. The SATs results at age 11 form the basis of the school performance tables published by DfES. These do not rank schools in order, but this analysis is carried out by the media to create league tables.

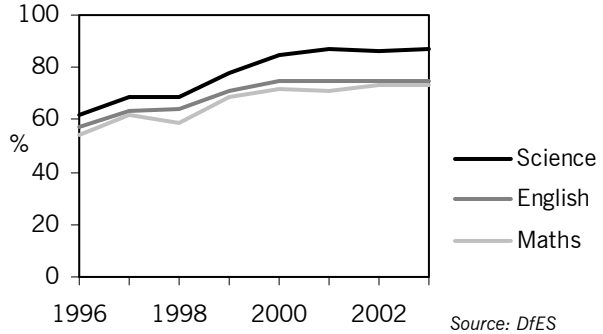
SATs were introduced from 1991 and 1995 for 7 and 11 year olds respectively and provide teachers with a snapshot of their pupils' attainment. However, since 1996 they have also been used to measure the success of national strategies and the performance of a school against national standards. For example:

- Science test results have been consistently better than for English and maths (see graph below). DfES uses this as evidence of the success of primary science.
- National targets were set for attainment at age 11 in English and maths tests to run alongside the literacy and numeracy strategies. Schools said that the targets put them under unreasonable pressure. In 2003, DfES pushed the targets back by 2 years to 2006 and gave schools more control over target setting at a local level. National targets have never been set for science.
- Ofsted, the school inspectorate, uses SATs results together with other indicators such as teaching quality to judge a school's performance.
- Parents use the test results as one means of choosing a school for their children.

Teachers

All primary teachers are trained to teach science as well as the other subjects of the national curriculum. They should then have opportunities to develop further their understanding of science throughout their careers (see box opposite). It is normal practice within schools to allocate one teacher as a coordinator or leader for each subject. Science coordinators are responsible for planning how the subject is taught across the school; ensuring that resources are available; and supporting other teachers and identifying their training needs. They do not necessarily have qualifications in science but training and support is available from subject associations such as the Association for Science Education.

Percentage of pupils achieving national expectations at age 11 in the SATs tests



Source: DfES

Current issues

Children's attitudes to science

Children tend to be enthusiastic towards science at a young age, as they explore the world around them. However, attitudes towards school subjects, including science, often become less positive when they transfer to secondary school. As a result, DfES is focusing its attention on secondary science. However, the primary years are seen as crucial in developing pupils' longer term interest in science. Further, recent research has suggested that children's interest in science may start to decline at primary school. Factors within primary schools that may affect pupils' interest in science, which are discussed in more detail below, include:

- whether science teaching is adapted by individual schools to reflect the interest of their pupils;
- the focus on preparation for SATs tests in the last year of primary school;
- primary teachers' level of scientific knowledge and confidence in teaching science.

Adapting the national curriculum for individual schools

Many teachers feel under pressure to focus on the factual content specified in the national curriculum as preparation for SATs. This can leave little time to build on children's interests; engage pupils in discussion on scientific ideas and issues; and teach scientific enquiry. QCA maintains that the NC offers enough flexibility, providing that schools plan their teaching well.

QCA's SoW have been widely welcomed as an aid to planning and are used by most primary schools. However, Ofsted has found that not all schools are adapting the science SoW to reflect the needs and interests of their pupils.[2] This could be because: some schools may believe that the SoW are statutory; SoW can be a crutch for teachers who lack confidence in teaching science; teachers do not have enough time to plan their own curriculum; and schools are unsure of how to adapt SoW to attain Ofsted approval.

Teacher training and professional development

Initial teacher training

Primary teachers qualify through two main routes: a three or four year undergraduate degree programme or a ten month Postgraduate Certificate in Education (PGCE). In 2002, 55% of recruits joined PGCE courses. Both courses train students in all the curriculum areas, though students can specialise in science. Any trainee born after 1979 must hold a GCSE in science at grade C or above.

Continuing professional development (CPD)

Teachers can gain professional training from three sources:

- Learning **from colleagues** informally or more formally through meetings with a subject co-ordinator.
- Advice from **Local Education Authority advisers.** DfES has funded literacy and numeracy advisers directly as support for national strategies. The support for other subjects, including science, varies between authorities.
- Attending **formal training courses**. Schools provide funding for individual teachers to attend courses. In addition, there are five days in the school year set aside for teacher training, but these usually focus on whole school issues rather than individual subject areas.

Similar issues arise in relation to the curriculum for older age groups. This has led QCA to propose a new curriculum for 14-16 year olds that specifies the skills of scientific enquiry, including an ability to handle broader issues in science, and leaves room for flexibility on factual content. [3] QCA has no plans at present to revise the primary science curriculum.

Coaching for SATs

Ofsted is concerned that some teachers are narrowing the curriculum during the last year of primary school to focus on SATs revision.[2] Schools report that they feel pressured to focus on SATs to help pupils get good results; to ensure a good Ofsted report; and to get a good position in the school league tables. Possible solutions include:

- **Amending SATs.** A common criticism of the science SATs is that they assess memory and repetition of facts, not scientific understanding. Some recent research suggested that children can give correct answers in the science SATs without understanding the underlying concepts. QCA increased the proportion of questions testing scientific enquiry from 2003. Many agree that this is a first step in the right direction.
- **Focusing more on teacher assessment.** If the marks awarded through teacher assessment had a higher profile, for example by forming a part of the school performance tables, schools might feel less pressure to coach pupils for SATs. QCA are supporting better use of teacher assessment (see box below).
- **Only using SATs to assess individual pupils.** Many believe that the publication of performance tables is a misuse of the SATs results. In Wales and Northern Ireland there are no primary performance tables although primary schools must publish their own results. However, DfES maintains that performance tables have been instrumental in raising standards in England, and has no plans to abolish them.
- **Abolishing SATs.** In Wales, SATs at age 7 were abolished in 2002 and testing at age 11 is under review. Some support abolishing SATs in England but others are wary of this option for two reasons. First, most agree that some form of assessment is necessary and so an alternative to SATs would be needed. Second, SATs brought science much higher status in the primary classroom. Without science SATs, there is concern that this would be lost – particularly if SATs remained for English and maths.

Strengthening teacher assessment in science

Teacher assessment is carried out continuously through the school year. There is currently no central guidance for teachers on how to carry out and use teacher assessment. As a result, practice between schools varies widely. Schools have asked for more support and QCA will be publishing new guidance in autumn 2003.[4] This will aim to introduce a consistent approach to teacher assessment so that results are comparable between schools. It will also help teachers to use the results of their assessment to inform their teaching. The guidance will focus on those areas where it is known that primary teachers have the most difficulty, including scientific enquiry.

Teaching primary science

Scientific knowledge

In the 1970s and 1980s, teachers' lack of scientific knowledge was seen as a major barrier to developing primary science. Primary teaching is a largely female profession and at that time few girls studied science other than biology. Today, primary teachers' scientific knowledge is widely recognised as having improved but the debate over the level and nature of scientific knowledge needed by a primary teacher in order to teach effectively remains active.

Some professional scientific institutions argue that factual scientific knowledge is paramount. This view is based on a concern that scientific misconceptions are being taught and reinforced in some classrooms. Misconceptions (for example, that the Sun moves round a stationary Earth) are often formed at a young age and are difficult to change. Ofsted has raised particular concerns over the physical sciences, where it reports that many primary teachers are working at the limit of their understanding.

On the other hand, Ofsted has found that the best teaching often involves scientific enquiry and some argue that the emphasis on factual knowledge distracts from this. The essential aim of scientific enquiry, to develop children's thinking skills, can be seen as the basis of any good primary teaching. However, there is concern that some teachers are unclear of the purpose of scientific enquiry, which prevents them from teaching effectively.

Teaching style

Some observers are concerned that teaching in science is more didactic than for other subjects. It is thought this might be caused by teachers' lack of confidence in their own scientific knowledge or lack of clarity over the reason why they are teaching science, particularly scientific enquiry. Ofsted reports that the quality of teaching in primary science has improved over the past five years, with teachers using techniques learned through the literacy and numeracy strategies to develop their science teaching. It is, however, concerned that the emphasis on literacy and numeracy in recent years has led to a reduction in both the amount of time spent on science and the amount of practical work carried out.

Teacher training and development

Ofsted reports that, overall, initial teacher training is very effective in preparing students to teach science.[5] However, those who complete an undergraduate course have better subject knowledge than those who complete the PGCE. Further, students' opportunities to practise their science teaching is limited because schools spend less time on science than on English and maths - in 2001, schools spent an average of 27% of teaching time on English, 22% on maths and 11% on science.

To encourage teachers to continue to develop their skills and knowledge after their initial training, DfES is now placing renewed emphasis on teachers' continuing professional development (CPD). Training in recent years has focused heavily on national initiatives in literacy,

numeracy and IT. From Autumn 2004 a network of science learning centres offering CPD for science teachers and technicians will be operational. DfES is establishing up to nine regional centres at a cost of £26 million while the Wellcome Trust, a charitable foundation, is funding a £25 million national centre. The centres are in time all expected to become self-financing. Although their focus will be on secondary science, training will also be targeted at primary science coordinators. A challenge may be persuading schools to release their science coordinators to attend courses, which may be disruptive for pupils, and to pay for both the cost of supply cover while the teacher is absent and for the course itself. As an incentive, fees will reduced for an initial period.

Science co-ordinators are widely seen as the route to strengthening primary science teaching. It has been suggested that, in addition to the training that will be available through the learning network, they need: better support from headteachers, who are rarely science specialists; more support from LEA advisers; co-ordination of teaching resources; and more opportunities to use resources such as science centres.[6]

School management

Ofsted is able to highlight the characteristics of schools with good practice in science education: teachers adapt schemes of work; their training needs are fulfilled; the NC is covered but time is still found to devote to specific issues of interest to the pupils; and pupils achieve good SATs results. As such, many people across education, research and government believe that the issues outlined above can be solved at the school management level. However, although science has the status of a core subject, in practice it is English and maths that are seen as the priority areas and that receive the most attention from school managers. The question then is how to develop and spread good practice in science.

Science as a separate subject

Science does not form a separate curriculum subject at primary level in all European countries. For example, in Scotland the subject of environmental studies draws science together with technology and social subjects such as geography, and this is seen as the most appropriate way to develop pupils' interests. Some argue that a similar approach should be adopted in England.

The NC in England as it stands does not prevent schools from teaching science either linked to one subject, such as technology, or taught across the curriculum. Rudolph Steiner primary schools, which have a distinctive educational philosophy, teach science with and through other subjects and, on the basis that this fulfils the NC, are in the process of applying for state funding. However, it is normal practice for primary schools to teach science as a separate subject, and schools may regard this to be the best preparation for the science SATs. Some advocates for science in England are concerned that integrating science with other subjects would lead to science loosing its status as a core subject and its apparent disappearance from primary classrooms.

The transition from primary to secondary

In 2002, DfES launched the science strand of a strategy targeted at teachers of 11-14 year olds.[7] One aim is to smooth the transition between primary and secondary school. For example, pupils often repeat material at secondary school that they have already been taught. This may be linked to the belief of many secondary science teachers that the SATs give an inflated picture of a pupil's attainment. DfES believes that these issues arise partly because secondary teachers do not fully recognise the differences between the primary and secondary curricula. The strategy encourages secondary science teachers to form closer links with their primary colleagues, for example by observing lessons. DfES believes that teachers have found this useful and that it has helped primary and secondary teachers to have a better understanding of their respective curricula.

Overview

Primary science teaching and pupils' performance in science SATs have improved significantly since the introduction of the national curriculum. However, there are concerns that this may not be sustained. Possible ways forward include:

- acting to reduce or change the impact of SATs testing on primary science teaching;
- reviewing the primary science curriculum;
- providing training for primary teachers to improve their scientific knowledge and confidence;
- encouraging school managers to see science as a priority area so that, for example, teachers are encouraged to adapt the curriculum to match the interests of pupils in their school.

One challenge is to avoid a potential conflict between preparing pupils for secondary school science while also maintaining and developing their interest in exploring the world around them.

Endnotes

1 The coat acts as an insulator, keeping the snowman cold so that it takes longer to melt.
2 *Ofsted subject reports 2001/02: science in primary schools*. Ofsted, November 2002. Available via www.ofsted.gov.uk
3 *Consultation on proposed changes to the key stage 4 national curriculum*. QCA, 2003. Consultation closed on 18 July 2003.
4 *Assessing progress in science*. QCA, September 2003.
5 *Science in primary initial training*. Ofsted, 2002.
6 For further information on science centres please see POSTnote 143 *Science centres.* July 2000. Available via www.parliament.uk/post
7 Key stage 3 national strategy. Further information available via www.standards.dfes.gov.uk

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology.

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