Finding the Optimum: The Science Subject Report

Introduction and background

In April 2021, Ofsted began publishing a series of research reviews which aimed to set out what the evidence says about a high-quality education across a range of subjects. At the time, Ofsted stated its intention that the research reviews would be followed by a series of subject reports. The first of these has now been published and is summarised below.
The science subject report evaluates the strengths and weaknesses of science in the schools inspected and makes a series of recommendations.
Ofsted is keen to point out that it will continue to evaluate schools against the criteria in the schools inspection handbooks, and that findings from these subject reports will not be used as 'tick lists'.
Throughout the report, there is reference to substantive and disciplinary knowledge. Substantive knowledge is the established knowledge produced by science such as the parts of a flower or the names of planets in the solar system. In the National Curriculum, this type of knowledge is referred to as 'scientific knowledge' or 'conceptual understanding.' Disciplinary knowledge refers to what pupils learn about how to establish scientific knowledge, for example by carrying out practical procedures. The term practical work which is used in the report refers to 'any teaching and learning activity which at some point involves the students in observing or managing the objects and materials they are studying.'

Key points and findings

Science education in England: Context

- Schools in England perform well above global averages in international comparison tests in science. Data from the 2019 'Trends in international mathematics and science study' (TIMSS) shows that Year 5 pupils' performance was relatively good, and broadly similar to that of pupils in 2015.
- However, Ofsted is concerned that the status of science in some primary schools has remained at a lower level since national tests in science were removed in 2009, and that this has affected key stage 3 performance. This is reflected in the decline of science performance at age 10.
- COVID-19 restrictions deprived many pupils of the opportunity to take part in practical activities. They also had a negative impact on the opportunities for many trainee teachers to teach a full science curriculum. Recruitment of specialist science teachers in secondary schools remains a challenge.

Main findings

- Most pupils, including those with special educational needs and/or disabilities (SEND), studied a science curriculum that was at least as ambitious as the national curriculum.
- Overall, the evidence gathered identifies some significant strengths in relation to science education in England's schools, in spite of the ongoing impact of the pandemic.
- Where science was strong in the primary and secondary schools visited, pupils had detailed and connected knowledge of the curriculum, and remembered what they had learned previously. Leaders and teachers were clear about the purpose of any teaching activity or specific content choice. They explained scientific ideas clearly and used assessment carefully to check what pupils had learned. This included disciplinary knowledge (knowledge of how to work scientifically) as well as substantive knowledge (established factual knowledge).
- In schools where science was strong, leaders generally saw the purpose of a curriculum as more than just a description of what pupils needed to know and do. They saw it as a 'path' which can make learning science easier. For example, the science curriculum was planned to take account of what pupils learned in mathematics.
- In a significant minority of schools visited, pupils were not developing secure knowledge of science. Often, in these schools, the focus was on covering content or completing practical activities. In both cases, the curriculum goal, that is what pupils needed to learn and remember, got lost. This led to pupils studying science, often for long periods of time, without developing sufficient substantive and disciplinary knowledge.
- Teaching was not always planned to ensure that what pupils learned next was related to what they already knew, so that they could build connected knowledge. In these schools, teachers' assessment rarely checked knowledge that pupils had learned in previous years.
- Across both primary and secondary, plans to develop pupils' substantive knowledge were much more developed than the plans to develop pupils' disciplinary knowledge. Often, this was because leaders had not sufficiently considered the kind of knowledge that pupils need to be able to work scientifically or carry out practical work generally. Too often in primary and KS3 the focus was on simply selecting practical activities for pupils to complete.

- Apart from physics or practical work where leaders had identified a training need, few schools had developed a systematic plan of how to develop teachers' knowledge of science and how to teach it.

Findings related to primary schools

- Ofsted found that science was taught weekly in most primary schools. However, in a few schools, pupils had less than one science lesson every week, and occasionally, pupils went for entire half terms without learning science – this is a concern.
- In most primary schools, leaders had considered how the curriculum in Reception supported pupils to learn science in Year 1 and worked together to achieve this. However, in some schools visited, the precise knowledge that children were expected to learn in Reception was not clear enough, and topics were too vague.
- Pupils took part in whole-class practical activities in a much larger proportion of lessons in primary schools than in secondary schools. Sometimes, practical activities covered too many aspects, and pupils were expected to learn too much disciplinary and substantive knowledge at once. Often, this was because they had not remembered or understood previously taught content.
- Teachers used stand-alone demonstrations of practical science in very few of the science lessons visited by inspectors. This is a concern, given that practical demonstrations have been shown to play an important role in helping pupils to learn science.
- In a very small number of primary schools, teachers and leaders assumed that pupils with SEND always learned best through carrying out hands-on practical activities. Perhaps this was due to the mistaken assumption that pupils have different 'learning styles'.
- CPD often focused on developing teachers' knowledge of working scientifically. There were very few examples of CPD taking place that focused on other areas of the science curriculum, for example developing teachers' knowledge of substantive concepts and how to teach them.

Findings related to secondary schools

- Many schools started teaching pupils GCSE content at some point during Year 9. However, in most cases, this did not lead to narrowing of the curriculum and topics were retained even though they are not assessed at GCSE.
- There were some weaknesses in curriculum planning. At times, objectives were too broad. There was also sometimes a lack of time for pupils to practice new content before moving on.
- Some schools recognised and checked prior learning at KS2, but in other schools, secondary subject leaders did not have a sufficiently clear understanding of what science pupils were expected to know from primary school. This had been exacerbated by COVID-19, as teachers had been unable to visit feeder schools.
- The focus in most schools was on developing pupils' knowledge of apparatus and techniques, as well as data analysis. There was little evidence of other aspects of disciplinary knowledge being developed, In some school curriculums, disciplinary knowledge was not sufficiently well integrated with substantive content. It was treated as a stand-alone block or unit.
- This study raised some concerns about the frequency and type of practical work taking place across secondary schools in England. In some secondary schools, inspectors did not see any practical work completed in lessons, either as a demonstration or activities carried out by pupils. In some school curriculums, the purpose of practical activities was not considered carefully enough.
- There was very little evidence of pupils developing their substantive and disciplinary knowledge at the same time, and then being given opportunities to undertake scientific enquiries and consider the methods which would be best.
- Inspectors observed some good strategies for formative assessment, including low-stakes quizzes, use of whiteboards, and well-targeted questioning. However, in some schools, assessment as learning was sometimes taking place at the expense of assessment for learning. For example, some pupils were asked to retrieve knowledge that they had not successfully learned in the first place. As a result, teachers were having to spend too much lesson time on teaching pupils the answers to the retrieval questions. This led to some pupils becoming confused and disengaged.
- Most schools assessed both substantive and disciplinary knowledge in key stage 3 assessments. However, some of the schools visited only checked substantive knowledge. This is a concern, given that the national curriculum requires pupils to develop their knowledge of the 'nature, processes and methods of science.'

Key recommendations

- Schools should plan the secondary science curriculum to build on what pupils learned in primary school, and not simply repeat it or assume that pupils learned little.
- Schools should ensure that enough time is built into the curriculum for pupils to learn and remember key knowledge.
- Schools should ensure that the curriculum identifies and sequences the disciplinary knowledge that pupils need to work scientifically. This should not be limited to learning about scientific techniques, data analysis or fair tests, but should include developing their knowledge of all areas of working scientifically.
- Schools should ensure that all pupils have enough opportunities to take part in high-quality practical work that has a clear purpose in relation to the curriculum. Subject associations and Ofsted should monitor the frequency and quality of practical work in schools, to make sure that all pupils have enough opportunities to take part in high-quality practical work.
- Schools should ensure that the science curriculum is planned to take account of what pupils learn, particularly in mathematics.
- Teachers should ensure that pupils have a secure knowledge of what has been taught, before moving on to more content. This should include checking whether pupils have specific misconceptions. Teachers should ensure that assessment checks whether pupils remember the substantive and disciplinary knowledge they have learned in previous years.
  School leaders should have a systematic and continuous approach to developing the science expertise of staff and leaders which is aligned with the school's curriculum and takes account of any specific needs and expertise.

The full documents can be downloaded from:

https://www.gov.uk/government/publications/subject-report-series-science