

Katherine Semar Schools
Science Best Practice Guide
Autumn 2021

The following information is based upon: The OFSTED Research review series: Science 29 April 2021, The OFSTED Best Practise Guide, Primary Science Quality Mark (Wellcome Trust), Maintaining Curiosity: a survey of Science in Schools (OFSTED), Computing and science: good practice guides for primary (The Key Leaders) and Working Scientifically in the Primary Classroom (CIEC) and PSTT.

Guidelines specific to Science

The new National Curriculum for 2014 sets out why we teach science in schools:

“Through building up a body of key foundational knowledge and concepts, pupils should be encouraged to recognise the power of rational explanation and develop a sense of excitement and curiosity about natural phenomena. They should be encouraged to understand how science can be used to explain what is occurring, predict how things will behave, and analyse causes.”

This report also highlights the importance of teaching science for understanding:

For pupils to achieve well in science, they must not only acquire the necessary knowledge, but also understand its value, enjoy the experience of working scientifically, and sustain their interest in learning it. Pupils in schools need to discover the concepts revealed through observing scientific phenomena and conducting experimental investigations for themselves. Then they are more likely to continue to study science and use that learning for work, for family, and to contribute as informed citizens.

Strands of Science

Science has three main strands:

- **Substantive knowledge** is organised according to the three subject disciplines: biology. chemistry and physics. Although each discipline is different, there are common concepts too, such as energy and the particle model. This means there should be a clear idea of when these are introduced into the curriculum. ([See PLAN resources for help with sequencing](#))
- **Disciplinary knowledge:** knowing how science establishes knowledge through scientific enquiry. This is described in the ‘working scientifically’ section of the national curriculum. It is imperative to note that this goes beyond simply doing practical work or collecting data. It includes learning about concepts and procedures that scientists use to develop scientific explanations. There are at least 4 content areas:
 1. Knowledge of methods that scientists use to answer questions – not just fair testing eg models, classification, pattern-seeking
 2. Knowledge of apparatus and techniques, including measurement
 3. Knowledge of data analysis
 4. Knowledge of how science uses evidence to develop explanations. This is how evidence is used alongside substantive knowledge to draw tentative but valid conclusions.
- The uses and implications of science today.

There is a risk that by categorising knowledge as either substantive or disciplinary, it is taught separately.

Disciplinary knowledge must be embedded within the substantive context of biology , chemistry and physics

Based on the above, high-quality science education may have the following features:

- Activities are carefully chosen so that they match specific curriculum intent.
- Pupils are not expected to acquire disciplinary knowledge simply as a by-product of taking part in practical activities. Disciplinary knowledge is **taught**.
- Scientific processes such as observation, classification or identifying variables are always taught in relation to specific substantive knowledge. They are not seen as generalisable skills.
- Teachers use systematic teaching approaches, where learning is scaffolded using carefully sequenced explanations, models, analogies and other representations to help pupils to acquire, organise and remember scientific knowledge.
- Teaching takes account of the limited working-memory capacity of their pupils when planning lessons.
- Pupils **are not expected** to arrive at scientific explanations by themselves without **sufficient prior knowledge**.
- Systematic approaches, alongside carefully selected texts, are used to teach the most important vocabulary in science.
- Pupils have regular opportunities in the early years and primary classrooms to learn vocabulary through story and non-fiction books, rhymes, songs and oral rehearsal.

Scientific Enquiry

In order for primary school children to operate as successful scientists, they should be **taught** a wide range of essential enquiry skills. These skills should build upon earlier opportunities they have had to play, explore, create, engage in active learning, and think critically in the Early Years Foundation Stage.

As previously mentioned, disciplinary knowledge should be taught in conjunction with substantive knowledge.

Enquiry-based teaching involves pupils acquiring substantive and/or disciplinary knowledge through exploration. This involves simulating the scientific enquiry process so that pupils develop their understanding of concepts using methods similar to professional scientists.

It is important to note that when the solutions to scientific problems are withheld from pupils, this significantly increases the cognitive load. This 'load' is further increased if pupils also manipulate apparatus. This explains why participating in 'discovery learning', in the absence of any guidance or sufficient prior knowledge, does not foster progress.

Eg. A controlled experimental study found that pupils' conceptual understanding of substantive science concepts was similar in both scaffolded enquiry and direct instruction. In contrast, 4- and 5-year-olds learned better when explicit teaching was provided before completing practical activities about floating and sinking. Similarly, withholding answers before an investigation on light meant pupils reasoned significantly worse than those pupils who had been taught what to expect beforehand.

Over the course of an academic year, pupils should carry out several investigations, which involve different types of enquiry:

- **comparative / fair testing**
- **research**
- **observation over time**
- **pattern seeking**
- **identifying, grouping and classifying**
- **problem solving**

It is important to note that teachers do not place an over-emphasis on fair testing. Furthermore, when fair testing is the focus of the enquiry, the full investigation does not need to be carried out each time e.g the focus may be on predicting with the other aspects being scaffolded to reduce cognitive load.

By carefully examining the statutory requirements for Working Scientifically at Key Stage One, Lower Key Stage Two and Upper Key Stage Two, it is possible to create a list of generic science enquiry skills common to all children across the primary age phase:

- asking questions
- making predictions
- setting up tests
- observing and measuring
- recording data
- interpreting and communicating results
- evaluating

The PSTT have produced a range of icons to go alongside each of these skills to help children to take more ownership and recognise these seven skills. Going forward we hope that these will help children to progress towards being more independent in UKS2.



It is important that teachers understand the progression route for each skill to enable them to plan high quality science lessons. In addition to the skills progression documents available, Upper Key Stage 2 teachers should be familiar with the progression of skills from KS2 to KS3 (PLAN documents)

Assessment Best Practice

- Feedback is focused on the science content and not on generic features. Teachers have sufficient subject knowledge to be able to do this (knowledge organisers available to support this).
- Pupils regularly retrieve knowledge from memory to help them remember and organise their knowledge. This is coupled with feedback. Teachers think carefully about what pupils are being asked to retrieve and whether this prioritises the most important content.
- Systems put in place to support teachers to make accurate decisions when assessing pupils' work are used. [See PLAN resources in Shared- Assessment- Science Assessment.](#)

Contexts For Learning

Best practice starts from a context which is meaningful and relevant to the children. Teachers use different contexts to maximise their children's engagement and motivation. This could be facilitated by a variety of approaches e.g. Mantle of the Expert or a topic launch.

Cross-curricular Links

Best practice in Science will develop skills within other areas of the curriculum: English, Maths, Computing and PSHE in particular. Where there is cross-over with maths, it is important that children follow the same procedures as they do in maths' lessons eg graph drawing, calculations etc. Many key life skills such as curiosity, confidence, risk-taking and resilience are developed within an investigative curriculum.

Additional Information from the OFSTED School Inspection Handbook – Sept 2015

Grade Descriptors for the quality of teaching, learning and assessment.

Note: Grade descriptors are not a checklist. Inspectors adopt a "best fit" approach that relies on the professional judgement of the inspection team.

Outstanding (1)

- Teachers demonstrate deep knowledge and understanding of the subjects they teach. They use questioning highly effectively and demonstrate understanding of the ways pupils think about subject content. They identify pupils' common misconceptions and act to ensure they are corrected.
- Teachers plan lessons very effectively, making maximum use of lesson time and coordinating lesson resources well. They manage pupils' behaviour highly effectively with clear rules that are consistently enforced.
- Teachers provide adequate time for practice to embed the pupils' knowledge, understanding and skills securely. They introduce subject content progressively and constantly demand more of pupils. Teachers identify and support any pupil who is falling behind, and enable almost all to catch up.
- Teachers check pupils' understanding systematically and effectively in lessons, offering clearly directed and timely support.
- Teachers provide pupils with incisive feedback, in line with the school's assessment policy, about what pupils can do to improve their knowledge, understanding and skills. The pupils use this feedback effectively.

- Teachers set challenging homework, in line with the school's policy and as appropriate for the age and stage of pupils, that consolidates learning, deepens understanding and prepares pupils very well for work to come
- Teachers embed reading, writing and communication and, where appropriate, mathematics exceptionally well across the curriculum, equipping all pupils with the necessary skills to make progress. For younger children in particular, phonics teaching is highly effective in enabling them to tackle unfamiliar words.
- Teachers are determined that pupils achieve well. They encourage pupils to try hard, recognise their efforts and ensure that pupils take pride in all aspects of their work. Teachers have consistently high expectations of all pupils' attitudes to learning.
- Pupils love the challenge of learning and are resilient to failure. They are curious, interested learners who seek out and use new information to develop, consolidate and deepen their knowledge, understanding and skills. They thrive in lessons and also regularly take up opportunities to learn through extra-curricular activities.
- Pupils are eager to know how to improve their learning. They capitalise on opportunities to use feedback, written or oral, to improve.
- Parents are provided with clear and timely information on how well their child is progressing and how well their child is doing in relation to the standards expected. Parents are given guidance about how to support their child to improve.
- Teachers are quick to challenge stereotypes and the use of derogatory language in lessons and around the school. Resources and teaching strategies reflect and value the diversity of pupils' experiences and provide pupils with a comprehensive understanding of people and communities beyond their immediate experience.

Good (2)

- Teachers use effective planning to help pupils learn well. Time in lessons is used productively. Pupils focus well on their learning because teachers reinforce expectations for conduct and set clear tasks that challenge pupils.
- In lessons, teachers develop, consolidate and deepen pupils' knowledge, understanding and skills. They give sufficient time for pupils to review what they are learning and to develop further. Teachers identify and support effectively those pupils who start to fall behind and intervene quickly to help them to improve their learning.
- Teachers use their secure subject knowledge to plan learning that sustains pupils' interest and challenges their thinking. They use questioning skilfully to probe pupils' responses and they reshape tasks and explanations so that pupils better understand new concepts. Teachers tackle misconceptions and build on pupils' strengths.
- Teachers give pupils feedback in line with the school's assessment policy. Pupils use this feedback well and they know what they need to do to improve.
- Teachers set homework, in line with the school's policy and as appropriate for the age and stage of pupils, that consolidates learning and prepares pupils well for work to come.
- Teachers develop pupils' reading, writing and communication, and where appropriate mathematics, well across the curriculum. For younger children in particular, the teaching of phonics is effective in enabling them to tackle unfamiliar words.

- Teachers expect and encourage all pupils to work with positive attitudes so that they can apply themselves and make strong progress.
- Pupils develop the capacity to learn from mistakes and they become keen learners who want to find out more. Most are willing to find out new information to develop, consolidate and deepen their knowledge, understanding and skills, both in lessons and in extra-curricular activities.
- Most pupils commit to improving their work. They are given time to apply their knowledge and understanding in new ways that stretches their thinking in a wide range of subjects, and to practise key skills.
- The school gives parents accurate information about how well their child is progressing, how well their child is doing in relation to the standards expected, and what their child needs to do to improve.
- Teachers challenge stereotypes and the use of derogatory language in lessons and around the school. Teachers promote equality of opportunity and diversity in teaching and learning.

Focussed areas identified from previous monitoring:

Exploit opportunities to build science vocabulary in the classroom by co-constructing vocabulary banks, use of Kos, modelling the use of STEM sentence starters and recording pupils' responses to aid assessment.

Well –reasoned explanations using specific scientific vocabulary.

Give pupils time to explore the equipment in order to formulate a plan and find answers to their questions.