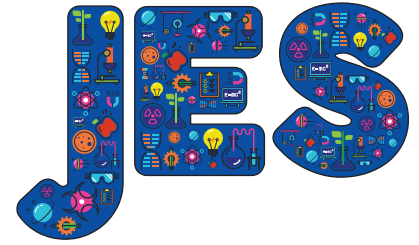


# Scientific enquiry and engaging primary-aged children in science lessons:...



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## ...reflections on provision for scientific enquiry in primary schools in England and Wales (Part 1)

### Abstract

The first part of this paper reflects on and discusses the concept of scientific enquiry in primary schools in England and Wales, including possible barriers to the provision of the primary science curriculum via enquiry. The second part of this paper, which will be published in Issue 14 of JES, will report and critically reflect upon how schools can deliver a high quality primary science curriculum via enquiry to engage children in science education and promote a lifelong passion for learning science.

**Keywords:** Barriers, curriculum, engagement, enquiry, perceptions, provision

### Children's perceptions of science

How do primary-aged (EYFS, Key Stages 1 and 2, ages 0-11) children view science? On the whole, is their attitude to learning about science and the world around them positive or negative? The Wellcome Trust (2014) notes that children start to 'develop perceptions about whether science is for them towards the end of primary school,' (2014: 4) and it is therefore imperative that *all*, not some, primary school children experience exciting and inspiring science that reinforces their understanding of the *nature of science*.

Although I now work in Initial Teacher Education (ITE), at heart I am a primary science teacher – and, as a science educator, nothing gives me more pleasure than engaging with children when they are learning science and with my student teachers when they are learning to be effective facilitators of the science curriculum. I have never met a child who is not curious and does not want to explore and investigate in science, unless they have

experienced the *boredom of not being taught science effectively* or indeed *learn to believe* that science is not for them.

We know from limited research into investigating primary-aged (0-11 years) children's attitudes to science that, in general, these pupils have positive attitudes to practical science and that this tends to emerge from a young age (Murphy *et al*, 2005; Silver & Rushton, 2008; Berland & Reiser, 2011; Tunnicliffe, 2015); thus they are likely, on the whole, to leave primary school – if they receive good provision in science education – thinking positively about science, even though primary-aged children can find some concepts in science difficult to understand (Loxley *et al*, 2014).

Teachers can find the more abstract concepts of science challenging to teach (Harlen & Qualter, 2014) and it is therefore recognised that more needs to be done to improve teacher effectiveness in developing children's conceptual understanding of science via enquiry, not only in primary but also secondary schools (Abrahams & Reiss, 2012; 2014). It is hoped that the changes to the Primary Science Curriculum in England and Wales (2013) will be a step towards enabling primary science classroom teachers to achieve this.

### The primary science curriculum and enquiry

As readers are no doubt aware, science in state maintained primary schools in England and Wales focuses on biology, chemistry and physics – via these disciplines, scientific knowledge and conceptual understanding are taught and developed. Scientific enquiry – referred to in the National Curriculum for Science as '*working*



*scientifically* – is an essential tool for children to ask and answer scientific questions about the world around them. Understanding the nature, processes and methods of science is an important aim of science education in the primary school:

- *'While it is important that pupils make progress, it is also vitally important that they develop secure understanding of each key block of knowledge and concepts in order to progress to the next stage. Insecure, superficial understanding will not allow genuine progression: pupils may struggle at key points of transition (such as between primary and secondary school), build up serious misconceptions, and/or have significant difficulties in understanding higher-order content.'*
- *'Pupils should be able to describe associated processes and key characteristics in common language, but they should also be familiar with, and use, technical terminology accurately and precisely. They should build up an extended specialist vocabulary. They should also apply their mathematical knowledge to their understanding of science, including collecting, presenting and analysing data.'*
- *'The social and economic implications of science are important but, generally, they are taught most appropriately within the wider school curriculum: teachers will wish to use different contexts to maximise their pupils' engagement with and motivation to study science'* (DfE, 2013:3).

In addition, *working scientifically* specifies the understanding of the nature, processes and methods of science for each year group and should be embedded within the content of biology, chemistry and physics, focusing on the key features of scientific enquiry, so that pupils learn to use a variety of approaches to answer relevant scientific questions.

These types of scientific enquiry should include:

- observing over time;
- pattern seeking;
- identifying,
- classifying and grouping;
- comparative and fair testing (controlled investigations); and
- researching using secondary sources.

*'Pupils should seek answers to questions through collecting, analysing and presenting data'* (DfE, 2013: 3).

*Working scientifically* will be developed further at Key Stages 3 and 4 (age 11-16), once pupils have built up sufficient understanding of science to engage meaningfully in more sophisticated discussion of experimental design and control (DfE, 2013: 4). Scientific process skills need to be developed, as they are the bedrock for children to be able to understand conceptual science, as well as engage in and enjoy science.

### Engaging children in science education via enquiry – considerations...

The collaborative, social constructivist approach to teaching and learning science does much to motivate and engage students in learning science, and teachers who focus on teaching science via enquiry, including curiosity and creativity to promote scientific thinking and reasoning skills, are in fact *'equipping learners with lifelong skills'* (Ofsted, 2013). The social constructivist learning perspective is ideal to facilitate an environment of working scientifically (Skamp & Preston, 2015), this being:

- the active process where children make sense of the world around them by linking new conceptual knowledge to their existing frameworks (the act of constructing knowledge on the basis of taking into account what is already known), ensuring that ideas and concepts in science make sense to them; and
- a way to develop understanding via the notion of learning from the more knowledgeable other; where pupils work together to search for meaning, understanding and/or solutions (Vygotsky, 1978), which provide just the right amount of challenge for those taking part – thus learning through communication and interaction with others.

The changes made to the Primary Science National Curriculum (2013) in England and Wales now emphasise the *whole scientific process*, this being a shift from the sporadic, occasional use of enquiry – often epitomised by teacher-led instruction or indeed class work restricted to a series of formulaic instructions, which inhibit independence (Ofsted, 2013) – to *working scientifically* being the way in which primary-aged children learn scientific concepts (Smith, 2015).



In addition to this, the curriculum recognises that children need to understand science as an 'ongoing' process, where primary-aged children are encouraged to understand that scientific ideas change and develop over time and see themselves as scientists in the classroom: '*the best teachers of science look for ways to enable their learners as scientists!*' (Cross & Board, 2014:17), rather than disconnected from 'real life' science.

Therefore, primary science needs to be embedded in issues that are meaningful to children and taught using pedagogies that engage children, as clearly highlighted by Bilton, Bento and Dias (2017) in their engaging book, '*Taking the First Steps Outside – Under Threes Learning and Developing in the Natural Environment*'. Primary science needs to be valued and taught regularly – the last point is particularly important; children cannot be expected to develop their process skills or conceptual understanding if science is not embedded in the curriculum and visited regularly.

Ofsted (2013) recognises that the most effective science teachers make it a priority to '*first maintain curiosity*' (Ofsted, 2013:4) in their pupils and, if this is adopted as a key principle in the teaching of science *via working scientifically* (via enquiry), then this will be fruitful in a number of ways:

- it will foster an enthusiasm and love for science whilst also promote the notion of scholarship in the National Curriculum – this is the idea that teachers should be fostering a love of lifelong learning;
- it will combat the stereotypical image of a scientist, which more often than not still, even today, predominantly involves a white man, in a lab coat, working alone in a laboratory strictly following the rules of an inflexible scientific method until he makes a discovery – no collaboration, no communication and no diversity. At some point in history, science has largely been the domain of white males, but this is no longer the case and children need to understand that diversity is not only now the norm, but also facilitates specialisation – the notion that different scientists who specialise in different areas within a field can indeed tackle the same topic from different angles, resulting in a deeper understanding of the topic. This is important for children in the primary school to understand if we want them *to see themselves as*

*future innovators and scientists* and if we want them to make links between science and other areas of the curriculum, e.g. maths or music; taking an in-depth, relational view of science, rather than understanding scientific concepts in an isolated or procedural way; and

- it will challenge '*the entrenched viewpoints which depict science as boring or just too difficult*' (CBI, 2015:3), so that some primary-aged children are not switched off from science by the age of 11, thereby enabling pupils to fulfill their potential.

### Possible barriers to engagement in enquiry in primary science

For some primary-aged children, barriers to learning and enjoying science can sometimes lie with the classroom teacher and his/her [lack of] teaching pedagogies (Sharp *et al*, 2011), as well as the learning environment. For some children, the learning of conceptual science is a challenge – the scientific vocabulary, counter-intuitive concepts, abstract concepts, scientific misconceptions that have already formed, the overuse of worksheets, use of disengaging teaching strategies or learning facts, do nothing to engage children in science learning (Allen, 2014; Loxley *et al*, 2014).

Perception of risk – risk is a necessary and importance part of science education; we cannot wrap up our children in cotton wool! Children need to learn how to assess risk when working scientifically, recognising aspects that are both positive (engaging with risk encourages children to be adventurous, brave and innovative, whilst developing decision-making and thinking skills) and negative – risking the possibility of failure, accidents or injury (Sandseter, 2010; Bilton, Bento & Dias, 2017). Risk avoidance, underpinned by a culture of fear by some teachers concerning the safety of children, does nothing to enable children to learn to work safely whilst working scientifically; teachers should be supported in this by being given continuing professional development (CPD) on planning for risk in science lessons.

Teachers' Pedagogical Content Knowledge [PCK] (Shulman, 1986; 2015) is also important; the inexperienced or ineffectual teacher can focus too much on children having '*fun via exploration*' rather than take pedagogical approaches that promote



understanding in science lessons. Of course, enjoying lessons is integral to engaging children in scientific learning – exploration and enquiry are crucial in developing process skills for children to construct their understanding of conceptual science. However, without a focus on scientific concepts, then the outcomes of enquiry will be just that – *fun*, without children progressing in their conceptual understanding of science. Sometimes during enquiry lessons, teachers can miss the opportunity to make explicit links between scientific concepts and the enquiry undertaken. This can happen for a variety of reasons, including time management issues; constraints in timetabling and resources; and a lack of pedagogical scientific content knowledge (Abrahams & Reiss, 2014).

It is argued that the status of primary science as a core subject has been eroded. This is not difficult to agree with when, on average, primary school children receive 5 hours of English and maths teaching per week in comparison to (at the most) 2 hours of science (Wellcome Trust, 2016). Cridland (2015) maintained that over half the teachers surveyed in the *Tomorrow's World* report [CBI] stated that they believed that the teaching of science in primary schools has become less of a priority. There are immense pressures on primary teachers to ensure that children perform in English and maths, as these are not only regularly monitored during 'Pupil Progress Meetings' and published in school league tables, but also inextricably linked to a class teacher's performance management! All of this, coupled with a lack of confidence for some primary teachers in subject knowledge of some areas of the science curriculum (Peacock & Sharp, 2014), as well as a shift in assessment procedures in primary schools (Roden & Ward, 2014), goes some way to account for scientific concepts not always being taught and assessed effectively in primary science lessons.

Resources – teachers who want to teach science via enquiry often find themselves very quickly challenged by the lack of resources available in schools to teach science effectively. The NFER Teacher Voice Survey (Wellcome Trust, 2016) found that, for the 805 primary teachers and leaders who took part in the survey from 740 different schools,

the most important barrier to teaching or leading science was the lack of budget and resources. Recently I was invited to take part in a Science Week at an inner London primary school, where the children were incredibly excited about their week ahead; however, the frustrations of some teachers were clear when one teacher confessed that, during an investigation, measuring jugs were needed to measure the growth of yeast, but the school did not have one measuring jug – anywhere – across the school.

Therefore, Senior Management Teams (SLT) should provide the resources (money, physical resources) necessary for teachers to provide high quality science education; SLT should also make provision for effective CPD to support teachers' knowledge, understanding and skills in science so that they teach and assess the correct conceptual science to *all pupils* via enquiry, including providing for the more academically able pupils (Wellcome, 2014; CBI, 2015). CPD needs to ensure that teachers are clear on scientific misconceptions, how to identify and reconstruct them (effective pedagogical approaches), both in their own subject knowledge and that of the children they teach (Allen, 2014), which should improve teachers' confidence in teaching science effectively.

Ultimately: teachers, school leaders and governors need to be clear on the *aims of primary science education and what is achievable*; high expectations of outcomes in science education for *all* children in primary schools is not simply an expectation from the government, but what each and every child *deserves!*

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