Different approaches to teaching primary science: the role of the teacher is what makes the difference

Alison Eley encourages teachers to focus on what is happening when effective teaching and learning are taking place in primary science classrooms

Over the last few years, the debate around the effectiveness of different approaches to teaching primary science has become increasingly polarised; this has played out on social media, in teacher blogs and magazines, and on occasion in this publication. Strong arguments are being made in favour of direct instruction, with equally strong voices advocating an enquiry-based approach. The danger of this polarisation is that teachers' understanding of the approaches becomes reduced to their 'worst' form: direct instruction is perceived as the teacher standing at the front telling the children all the facts they should know, with children repeating these over and over, while enquiry-based learning conjures up a picture of children engrossed in chaotic and directionless practical work. These characterisations are inaccurate, and very unhelpful for teachers.

When teachers are planning their science lessons, consideration of their own role and the quality of the dialogue they have with the children is key. I suggest that this is more important to the success of any approach than the nature of the approach itself. Although this article does make the case for practical, enquiry-based approaches being essential, it is primarily encouraging teachers to recognise when and why a particular approach might be best for a specific learning intention.

Before exploring the role of the teacher, we should step back a bit and consider the purpose of teaching science in primary schools, as well as the place of science in the overall primary curriculum and its contribution to the wider aims of primary education. Development of a child's science capital and their agency as a learner are also important underpinning considerations and these will be discussed.

The purpose, place and wider aims of teaching science in primary schools

This is a vast topic in itself, but there is broad agreement in the literature (e.g. Furtak *et al*., 2012; Harlen and Qualter, 2018) that the purpose of primary science is for children to develop:

- scientific skills;
- knowledge and understanding of some scientific concepts;
- positive attitudes to science;
- an understanding of the nature of science;
- an appreciation of the applications of science and its value in the wider world.

There are common themes across all UK curricula about the overall aims of primary education. These include supporting children to become confident and healthy individuals, informed and responsible citizens who appreciate the value of scientific endeavours and their impact on

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progress in society, effective and creative contributors, and ambitious and successful learners who are well prepared to live fulfilling lives.

All four UK curricula specify that children should engage in problem-solving activities and open-ended thinking tasks, to have opportunities to take responsibility, to develop self-management skills and intrinsic motivation for tasks, to work in groups and collaborate with others, and to learn to communicate effectively.

Achieving these wider curriculum aims means giving children opportunities to be creative and to follow their own curiosity, to engage in open-ended exploratory activity and to make mistakes, and to think for themselves and make decisions about their own learning. Primary science education has a pivotal role to play here, and enquiry-based approaches are central to this. The rationale for adopting an enquiry-based approach to primary science has been clearly established in the literature (e.g. Harlen *et al*., 2012; Dunlop *et al*., 2015; Harlen and Qualter, 2018), but consider further: if primary science becomes simply about knowledge acquisition, it is ignoring its responsibility for supporting the delivery of the wider curriculum aims. Or, put the other way round, when primary science offers enquiry-based learning, it is playing a key part in delivering and enriching the wider curriculum.

Science capital and children's agency and identity in science

Research has shown that children's attitudes to science and ambitions to pursue a science-related career are set before they leave primary school (Archer *et al*., 2013; Archer and DeWitt, 2016). For children to develop positive attitudes to science, and their own science identity, they need to see its relevance to them and their own lives (see *Primary Science* **154** which has the theme of 'science capital'). The Primary Science Capital Teaching Approach outlines how personalising the child's learning, starting from what they already know and actively looking for opportunities to make them the expert in science lessons, all help to build their science capital. Also key to a positive science identity are enjoyable and immersive practical science experiences.

Immordino-Yang (2021) encourages teachers to recognise that, while schools and school systems can be made efficient, the process of learning cannot. She argues that many schools today are not supporting children to have agency in their learning and that the focus on behavioural outputs (e.g. producing right answers) is not only taking away the opportunity for children to develop the capacity to do things for themselves, but also precipitates higher anxiety. She points out that during the process of learning, children will become proficient in things that they will not necessarily need to do when they are adults. A good example is crawling: it is an essential stage of development, but not something needed in adult life. The purpose of a child engaging in enquiry-based science activity is not in order for them to be able to replicate the exact same process as an adult, but because they will develop transferable skills, independence and agency, and an identity as a scientist.

The role of the teacher

It can be helpful to think about the role of the teacher during different moments in a science lesson. Consider the possible lesson sequence shown in Table 1, on changes of state as part of a materials topic. If we break down the lesson, we can begin to see how the role of the teacher at each stage supports the development of the children's understanding, not just of scientific concepts but also of the scientific process and the nature of science. Note, this is not setting out to be an exemplar lesson; rather it is an illustration of some commonly used activities with some analysis of the role of the teacher in effecting learning.

Table 1 A lesson sequence demonstrating the changing role of the teacher

Children aged 9–11 **Topic: Changes of state (focus on evaporation and condensation)**	**Approach being used and the role of the teacher**	**What the children are doing**
PART 1 Teacher asks children to think about whether they have ever noticed, and what they think is happening in, a particular scenario, e.g.: ● When a puddle dries up in the playground. ● When they or someone else is wearing a facemask at the same time as glasses. ● Their breath when they go outside on a cold day. ● When a mirror or window gets 'steamed up' and they can draw pictures or write on it with their finger.	**Guided discussion** Stimulating thinking and discussion with open-ended questions, eliciting the children's existing knowledge and understanding, identifying misconceptions, personalising the learning through drawing on experiences of particular children and making them the 'expert'.	Thinking and reasoning about what they have observed, linking ideas to existing knowledge and understanding. Discussing ideas to refine and improve them through collaboration.

Table 1 cont'd. A lesson sequence demonstrating the changing role of the teacher

PART 1 cont'd Teacher facilitates feedback and whole-class discussion.	**Direct instruction: repetition/ reinforcement** Modelling and encouraging correct use of vocabulary and terminology.	Improving their tentative explanations and rehearsing using correct scientific vocabulary.
Teacher uses practical demonstration of evaporation and condensation and asks the children as a group to create an explanation about why water droplets form on the underneath of the cling film (Figure 1).	**Direct instruction: practical demonstration** Prompting the children to observe closely, and to apply their previous thinking and explaining to a new scenario.	Thinking and reasoning to develop a new explanation using vocabulary practised earlier, working collaboratively.
PART 2 Teacher shows children a beaker of water and asks how they could get it to evaporate as fast as possible in the classroom. Each child/group decides what they will test (e.g. temperature of where the container is placed, shape of the container, starting temperature of the water). Children select equipment and set up and carry out their test as individuals or as groups.	**Enquiry-based: open-ended, i.e. with some free choice for children** Facilitating group discussion, encouraging the children to link predictions with previous learning and understanding. Questioning the children about their rationale for what they are doing, asking them to explain their predictions and how they will measure the outcomes.	Developing predictions based on evidence from previous learning and personal experience. Making informed choices about what to test. Actively engaging with the scientific process, reasoning and explaining what they think will happen and why. Collaborating and considering the ideas of others.
PART 3 (after time allowed for water to evaporate) Teacher asks children to observe and measure what has happened, and then describe and explain these findings.	**Enquiry-based with guided discussion** Encouraging the children to review their own measurements and to link their measurements and observations to what they already know.	Thinking and reasoning to generate explanations, linking their own experimental findings to existing knowledge and understanding.

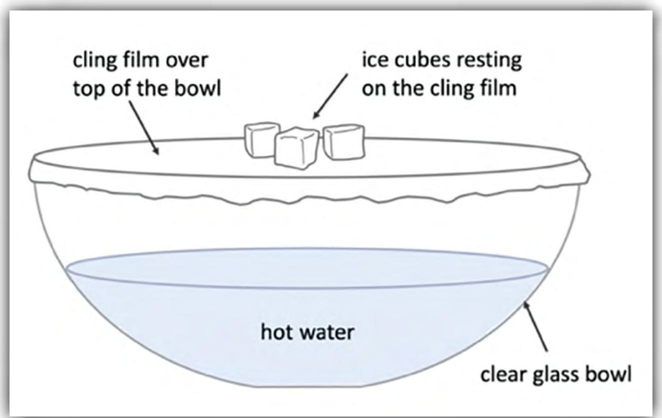

Figure 1 Evaporation and condensation demonstration

Key points that emerge from this lesson analysis:

- a mixture of approaches is woven through the lesson;
- it gives potential for the children to be fully engaged in thinking, talking and doing;
- personalising the lesson and starting from the children's experiences develops their science identity;
- the hands-on enquiry offers some free choice and gives the children agency as learners;
- the open-ended enquiry supports the wider aims of the primary curriculum;
- a direct-instruction approach is necessary for introducing key scientific terminology;
- not all scientific concepts can be learned through enquiry alone;
- actively doing practical enquiry gives children opportunities to learn about enquiry and the nature of science.

Further consideration of the last point: can children learn about the processes of science without doing science enquiry themselves?

A teacher-directed practical science investigation (very often carried out in order that the children arrive at a predetermined outcome, e.g. to prove a concept to be true or to practise carrying out a fair test) is not enough for children to learn about the processes of science. Think about baking a cake: if you follow a recipe precisely, you would hope to end up with an edible cake that looked like the picture. While making the cake, you might be learning and practising some new baking skills, and some of these would be transferable to new situations. But it offers you little opportunity to develop an understanding of the whole process of baking. It is through independent experimentation that you will find out what difference it makes to the outcomes of your baking if, for example, you change the types and amounts of ingredients or experiment with the oven temperature.

Different approaches and the role of the teacher – stop and think

The questions listed in Table 2 can be used as prompts or a checklist when planning a lesson or activity to ensure that the purpose of learning science and the wider aims of primary education have been considered. Note, this is not an exhaustive list of things to consider and neither is the order hierarchical. As Kuhn (2007) reminds us, what you ask of your approach must be dependent on who and what you are teaching, and why you are teaching it.

Find out more

To find out more about the Primary Science Capital Teaching Approach and download a pdf or order a hard copy of the Teacher Handbook go to: www.ucl.ac.uk/ioe/departments-and-centres/departments/education-practice-and-society/stem-participation-social-justice-research/primary-science-capital-project.

Table 2 Some questions to consider in lesson planning

Will the lesson/activity give opportunities for the following?	Why is this important for primary science and wider curriculum aims?
Personalising the learning and for children to take on the role of the expert.	Builds science capital. Makes science and science knowledge relevant.
Learning and using scientific vocabulary with understanding.	Enables clear communication about science with others and lays foundations for future learning of science concepts.
Developing children's natural curiosity.	Develops intrinsic motivation and agency in learners.
Considering why a wrong idea might be wrong as well as why a right idea might be right.	Helps stop children 'holding on' to prior misconceptions. Develops an understanding of how scientists work.
Encouraging children to be creative in their learning.	Develops problem-solving skills. Develops independence and agency.
Engaging in purposeful group work and making decisions as a group.	Builds collaboration and cooperation skills.
Thinking and reasoning.	Supports children to construct their own understanding and develop as independent thinkers.
Discovering something the children (and maybe the teacher) weren't expecting.	Builds an understanding of the nature of science and how scientists work.

Summary

This article has explored the multi-layered nature of primary science teaching and suggested that direct instruction and enquiry-based approaches should not be seen as an either/or. It has set out the importance of enquiry-based learning in primary science and of recognising the value of this to wider curriculum aims. This does not mean that other approaches do not have value, but problems arise when direct instruction is presented as an alternative to enquiry-based learning rather than as a complement to it. This is a distraction for teachers, taking the focus away from their own role, and how this facilitates the progress the children make in their learning.

Alison Eley is the Outreach Director for the Primary Science Teaching Trust.
Email ali.eley@pstt.org.uk

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