What is BEST for primary science?

Nicky Waller explains the BEST approach to teaching and assessing science, with details of how this is being piloted successfully in primary schools

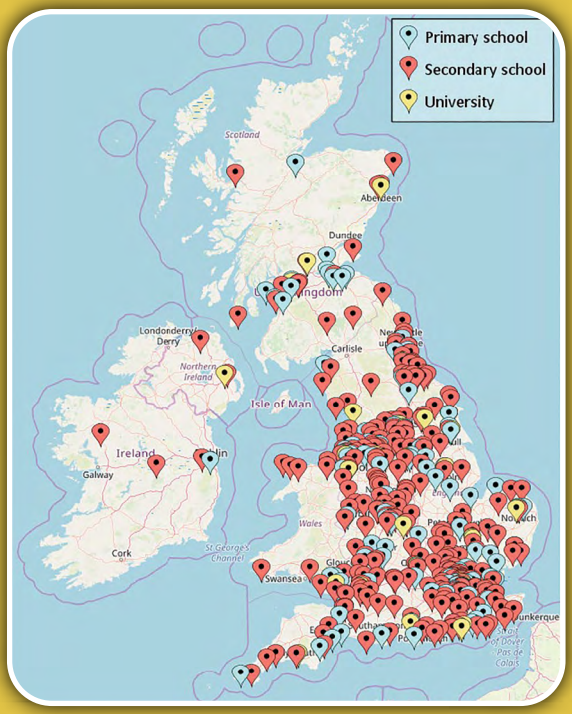

Figure 1 One quarter of all downloads of secondary BEST resources are by primary schools

A little background

Best Evidence Science Teaching (BEST) is a large online collection of resources developed for effective teaching of difficult ideas in science, currently for use in secondary schools. The unique selling point of BEST is that it enables teachers to draw on the best research evidence when teaching a wide range of topics in the science curriculum. The comprehensive suite of resources is intended to help students to make progress in understanding key concepts in science education and support teachers in developing evidence-based practice.

The secondary BEST resources have been developed by the University of York Science Education Group (UYSEG) and funded by the Salters' Institute, a charitable body that works to support science education. The initial funding was for four years (2015-2019) to develop resources for the 11-14 age range. The very positive reception given to BEST by teachers and others involved in science education resulted in the Salters' Institute agreeing to fund (i) the extension of BEST to cover the 14-16 age range, and (ii) a small-scale pilot for BEST materials for the 9-11 age range, to be conducted by the Centre for Industry Education Collaboration (CIEC) in collaboration with UYSEG.

Teachers' views of BEST

All the current BEST resources are free and open access, and are hosted online by STEM Learning at www.BestEvidenceScienceTeaching.org. Key indicators of levels of uptake are the figures on page views and downloads of the resources from STEM Learning's website. Several months after the launch of BEST, the figures were described as 'significant successes' by Yvonne Baker, the Chief Executive of STEM Learning.

One notable feature of the data is that around 25% of the downloads are by primary schools, indicating a level of interest in primary-focused BEST resources.

CIEC conducted the pilot in collaboration with UYSEG during the 2020-21 academic year, with the aim of uncovering whether or not there is a genuine interest from primary teachers to develop BEST resources for the primary school age range.

BEST for primary?

In October 2019, CIEC carried out a feasibility study to analyse the potential reach of the 'BEST approach' to support science teaching and learning in the primary school. A full scrutiny of existing BEST resources explored whether the structure of BEST lends itself to the primary age range. Suggestions were also made regarding which elements of BEST might need adapting to suit the age 9-11 phase in the initial instance, but also whether there is potential to use and adapt the same structure for younger primary-aged children and their teachers.

Based upon the positive outcomes of the feasibility study, the Salters' Institute agreed funding for the Primary Pilot Study with primary teachers from around the country to further establish the potential interest and impact of BEST on primary science.

Key words: Formative assessment ■ Diagnostic questions ■ Children's misconceptions ■ Research evidence

BEST Primary Pilot Study: Phase 1

The pilot study began in April 2020, with twenty teachers recruited from primary schools in Yorkshire and the North East of England, who were given the opportunity to help shape the development of BEST primary resources from the outset.

Ten of these schools were allocated to Phase 1 of the pilot and asked to feed back on a selection of draft primary BEST activities that had been adapted from existing 11-14 resources to complement the following Year 5 (age 9-10) topics in the English National Curriculum for Science:

Science topic/area	Content at the upper primary level
Living things and their habitats	The diagnostic questions link with popular biology topics in which children learn how to identify and compare simple features of living things, and sort these into groups based on common observable characteristics.
Properties and changes of materials	The diagnostic questions link with popular chemistry topics in which children learn about properties and uses of everyday materials.
Earth and space	The diagnostic questions link with popular physics topics in which children learn about the Earth, space and our place in the universe.

Each activity contains comprehensive teacher notes aimed at supporting primary teachers to run the activities with children aged 9-11 years.

All teachers in Phase 1 attended virtual feedback meetings whereby they shared their thoughts on how useful and useable the resources would be for them, how well they thought they might work with their classes, and ways in which the activities might be improved for a primary audience. Feedback was extremely positive, with primary teachers reporting that the diagnostic questions provided ample opportunities to encourage discussion in the classroom, as well as being excellent 'ice-breaker' activities to aid with pre-assessment at the start of a key scientific concept.

Quotes from primary teachers in Phase 1 of the pilot study include:

'I think all of the resources are really useful and would be easy to use in the classroom. The resources all encourage open-ended discussions that allow for assessment of children's prior knowledge, but also encourage the use of scientific vocabulary to justify their opinions, which I think is extremely valuable'

'It is great that the misconceptions are identified and this is good for teachers that are not sure themselves'

'In my class I believe the resources would work well. The children love discussions and adding to each other's ideas. I think this would give the class a good opportunity to begin challenging one another's views in a mature way'.

Figure 3 Children justifying their ideas in different corners of the classroom

BEST Primary Pilot Study: Phase 2

All twenty schools participated in Phase 2 of the pilot study, from April to July 2021. Teachers received updated versions of the draft resources, amended and adapted to make them more suitable for use in primary schools in light of responses provided at the feedback meetings.

In addition to this, several primary schools from Stoke-on-Trent also became involved in Phase 2 of the primary pilot study, with the aim of using the draft resources as the starting point for a city-wide diagnostics support package. Headteachers in Stoke had been searching for a consistent suite of tools for use in all schools to better support transfer from Years 6 to 7 (age 10-12) and believed BEST to be the only researched and thorough tool to recommend.

For each activity, pilot schools received a Word document comprising a pupil activity sheet and teacher notes, plus a PowerPoint presentation for use on screen in the classroom. All teachers were asked to try the activities in class and then provide their thoughts through an online questionnaire or more in-depth interview. Five of the twenty schools agreed to the observation of a science lesson in which the resources were being used.

Getting to grips with diagnostic questions

Diagnostic questions are at the heart of BEST and are intended to help teachers collect evidence of what

Figure 2 Year 5 child responding to diagnostic question: Is it a bird?

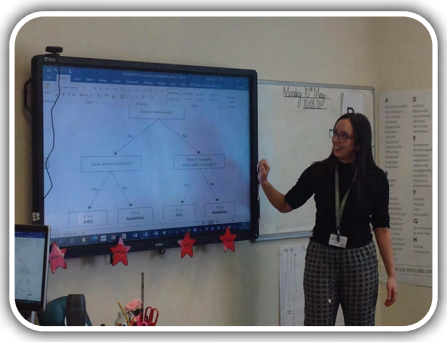

Figure 4 Teacher introducing a classification key

the children in their class are thinking, including:

- what they currently understand; and
- any preconceptions and misunderstandings they may have.

The diagnostic questions are designed to target particular preconceptions and misunderstandings that have been reported in the research literature as being common in children of this age.

They are intended to function as formative assessment items: the evidence they provide about what children are thinking can help teachers to decide what to do next in terms of focusing and sequencing their teaching.

It's up to individual primary teachers how to make best use of the diagnostic questions. For example:

- you might choose to use them at the start of a lesson, or partway through, or at the end – whatever you feel will give you the best information about what the children are thinking; and/or
- you could ask children to respond in different ways, for example by voting on the answers using mini-whiteboards or by moving to different corners of the room, or by simply recording their answer on the activity sheet.

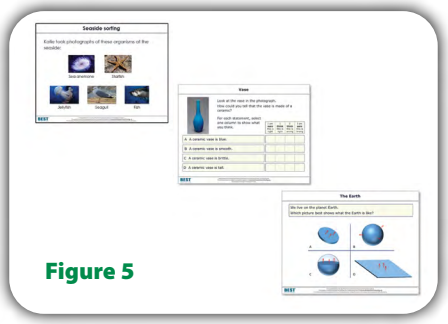

Figure 5

Uncovering children's misconceptions

The recent Ofsted review of factors that influence the quality of science education in schools in England (Ofsted, 2021) explores the literature relating to high-quality school science curriculums, assessment, pedagogy and systems. The research states that *'There is a clear relationship between young children's general science knowledge and their later science achievement. If gaps in pupils' knowledge are not addressed early on, evidence suggests that these will continue into secondary school and beyond'* (Morgan *et al,* 2016, pps.18-35).

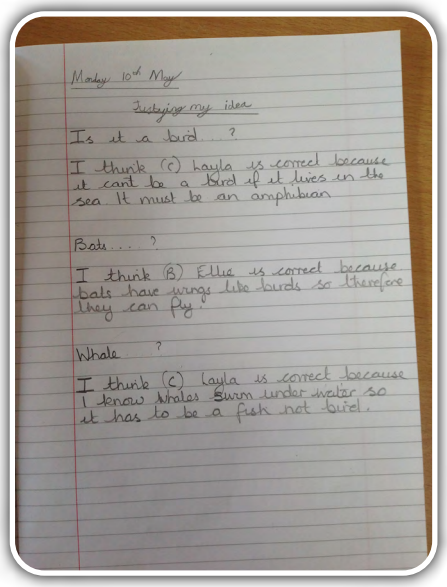

Figure 6 Revealing common misconceptions at upper primary

Throughout the review, there is an importance placed on pupils taking a *'metacognitive perspective'* by needing to not only know why a scientific idea is correct, but also why their misconception (prior knowledge) is scientifically wrong. Ofsted suggests that *'The curriculum should anticipate where pupils are likely to hold misconceptions. These are explicitly addressed, and pupils learn how the misconception is different to the scientific idea'* (Ofsted, 2021).

During Phase 2 of the primary pilot study, teachers commented on how useful the BEST diagnostic questions had been in revealing a wide range of, often incorrect, scientific ideas that children bring with them to their lessons. Some examples of this type of highly revealing dialogue are included next:

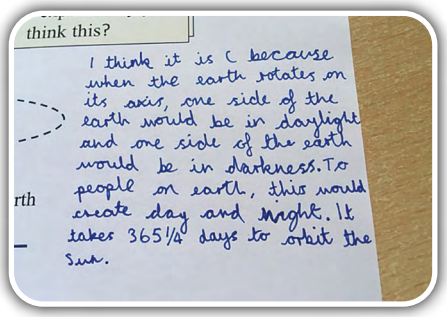

Figure 7 Opportunities for children to show existing knowledge and understanding

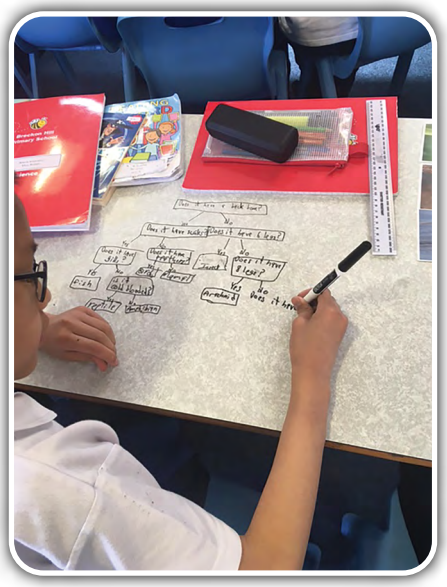

Figure 8 Diagnostic questions leading to response activities

Example 1

C1: A penguin can go on water and on land so is an amphibian.
T: That's right, it can, but why is it not an amphibian?
C2: Because a penguin doesn't go right under the water so that doesn't count.

Example 2

C1: Does a penguin actually have feathers?
T: If you haven't seen one, you wouldn't really know. They look quite smooth like smooth skin but [are] actually feathers clustered together to keep them warm in their environment.
C2: What if you had a bird and shaved all its feathers off? It wouldn't be a bird then.
T: That's because you have changed it but the bird does have feathers naturally.

Example 3

C1: The Moon will be facing one side of the Earth, which will be night.
T: What has the Moon got to do with it?
C1: When the Earth faces away from the Moon it will be day.

Progression toolkits: more work to be done for primary

The original resources in the BEST collection are not intended as stand-alone activities. Each one is part of a progression toolkit for a key concept taught in secondary school science.

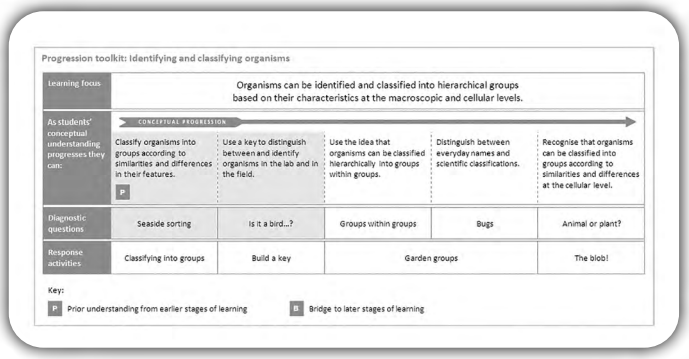

Figure 9 Example progression toolkit, age 11-14

The first two rows of the pathway describe what students should be able to do as their understanding of the key concept develops – this takes the form of observable learning outcomes to guide the teaching focus. An example from the 11-14 progression toolkit for the key concept *Identifying and classifying animals*, taken from a biology unit of work, is shown in Figure 9.

The P symbol shows that the first statement indicates prior understanding from earlier stages of learning. This would link back to what students have been learning at the primary school level and would be a good end point for a primary pathway.

The middle column in each progression pathway indicates the level of conceptual understanding that a student aged 11-14 might have, in order to be categorised as working at the 'expected standard' for this particular area of learning. Organising the pathway in this way enables teachers to make consistent judgements for students working towards or above the expected standard.

Although the development team at UYSEG and CIEC has not yet developed any progression toolkits or response activities for BEST Primary as part of the pilot study, they intend to do so if the pilot is taken forward into a full curriculum development project. Progression toolkits for the primary age range, like the secondary models, would need to be based on careful consideration of available research evidence on learning pathways, common student misunderstandings, and effective teaching approaches at the primary level.

Feedback so far

At the time of writing this article, feedback had been gathered from a small number of primary schools through lesson observation and detailed teacher interviews. The overall response from both children and teachers has been overwhelmingly positive, with the use of diagnostic questions revealing often unanticipated misconceptions and then moving the learning forward from useful, informative starting points. Some examples are given below:

Feedback from teachers

'I think the whole feel of the lesson was it's okay if it's wrong, then they were more open to trying it. I think sometimes when you do open it, they come up with better ideas than what I would think of.'

'I would have made a lot of assumptions about their knowledge and understanding of different animals without these activities.'

'I feel that I considered more of their knowledge in understanding where they need to go next, whereas I think if I'd probably done it without these resources, I just would have stuck a load of pictures of different animals and probably not even thought about the fact that, well do they know that a penguin doesn't have this or that characteristic?'

Feedback from children

'I enjoyed learning about animals in this different way.'

'I liked going into the different groups in different corners of the room to show what I understood and then explaining why I thought this to others in my class.'

'I liked the guessing parts, sharing our thoughts and listening to other people's ideas.'

What next for BEST Primary?

The final phase of the pilot study will be for CIEC and UYSEG to collate all feedback received from Phase 2 teachers and produce a summary report in Autumn 2021. If the feedback is as positive as we anticipate, we hope to expand the number of BEST resources aimed at the primary age phase and create a more extensive and established primary collection, including subject maps, progression toolkits and response activities.

Interested in getting involved?

CIEC would love to hear your thoughts on the expanded development of primary BEST and whether you would welcome the creation of a full complement of resources for Upper Key Stage 2 children, as well as a suite of diagnostic questions for younger children, eventually covering the full primary age phase.

We would also love to hear from primary teachers about which elements of the existing BEST resources you feel that you would value the most, such as subject maps, progression toolkits, diagnostic questions, response activities and teacher notes.

CIEC will be looking for primary schools and teachers from around the country to take part in further stages of this exciting pilot study. Please do get in touch if you are interested in signing up and getting involved.

For further information about exciting developments regarding BEST for primary schools, please contact: joy.parvin@york.ac.uk or nicola.waller@york.ac.uk

References

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Nicky Waller has been working as an advisory teacher for CIEC since 2004 and is passionate about building teachers' and children's confidence in all things primary science.
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