Embedding assessment to improve learning

Mary Whitehouse

ABSTRACT The traditional plan of teaching science content and then deciding at the end what to ask in an examination is challenged in this presentation, which starts the planning at the other end of the process. The intention is to consider the topic, decide what children should know and be able to do by the end, then structure the teaching, with assessment taking place throughout so that successful outcomes can be achieved.

The *York Science* project is developing questions and tasks that will provide evidence of learning for all the key ideas in key stage 3 (ages 11–14) science. We believe that these assessment items can support teachers in two ways:

- when used in the course of a lesson, the tasks and questions will provide information about where the students are in their learning and what should happen next in the lesson;
- thinking about the assessment items to be used in a lesson *first* helps clarify the learning intentions of the lesson.

Embedding assessment in planning

Writing learning intentions for a scheme of work is not enough, it is the questions and tasks that show what we would want students to do as a result of the learning that make the intention clear.

With a new programme of study for key stage 3 just published (Department for Education, 2013), teachers will be rethinking their key stage 3 schemes of work. How would you approach this if you want to embed assessment in your planning? Figure 1 shows the *York Science* approach to this.

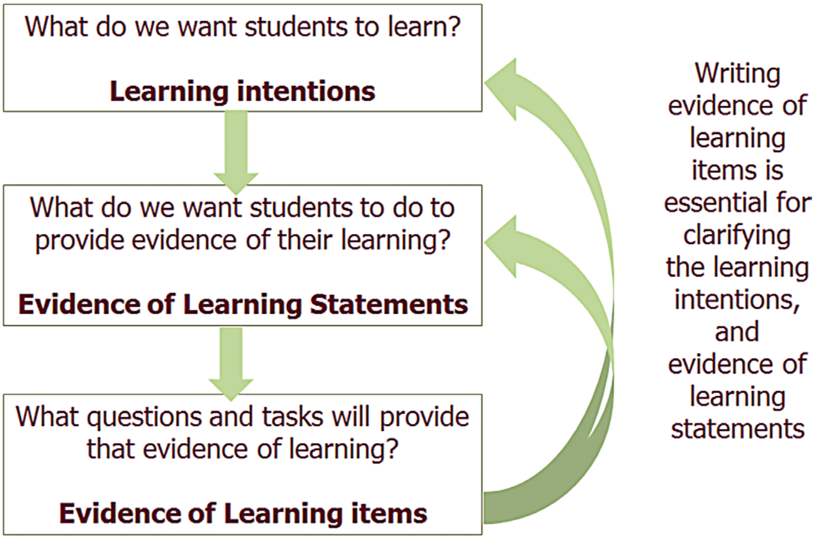


Figure 1 A planning process that focuses on evidence of learning

How would this look in practice? The programme of study (Department for Education, 2013: 8) has a section headed 'The particulate nature of matter' for which it states that pupils should be taught about:

- *the properties of the different states of matter (solid, liquid and gas) in terms of the particle model, including gas pressure*
- *changes of state in terms of the particle model.*

We begin by writing a learning intention:

Understand a basic particle model of matter that can explain states of matter and changes of state.

(This intention does not cover gas pressure; this will be covered by a separate learning intention.)

But how will we know that students understand the particle model of matter? And what do we mean by understand anyway? The only way we can know what understanding students have is by finding out what they can do.

The next stage is thus to describe the things we want students to be able to do at the end of this teaching sequence to show that they understand a basic particle model of matter that can explain states of matter and changes of state. For example, students will be able to:

- describe the main features of the particle model;
- identify limitations in representations of the particle model;
- use the model to explain characteristics of substances in the solid, liquid and gas states;
- use the model to explain changes of state.

Next we collect together tasks and questions for each of these evidence of learning statements; we call these 'evidence of learning items' (ELIs). Writing these items helps clarify the learning intentions and evidence of learning statements, and may lead to editing of those statements.

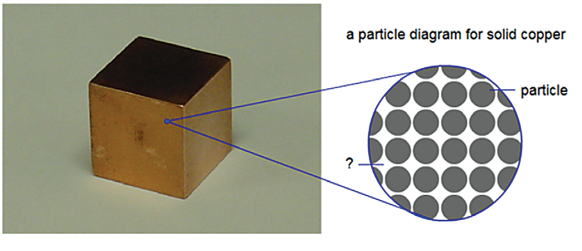
Once you have clarified your learning intentions in this way, you are in a position to plan the teaching that will bring about the learning you are looking for.

Diagnostic questions

The best kinds of questions and tasks to use in formative assessment are those that not only tell you which students have some understanding of the idea but that also give you some information about the thinking of those who have not yet gained a scientific understanding. We call these *diagnostic questions*. Figure 2 shows such a question.

The question in Figure 2 was developed for the Assessing Students' Concept of a Substance project at Durham University (Johnson and

Science has the idea that 'stuff' is made of very small particles – too small for us to see. Imagine you could see these particles.



What is between the particles?

A Air

B Solid copper

C Empty space – nothing

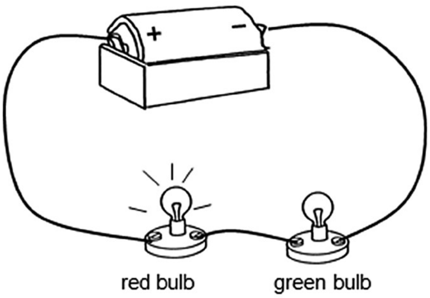
D More particles which aren't shown

Figure 2 A diagnostic question to explore students' understanding of the particle model of matter

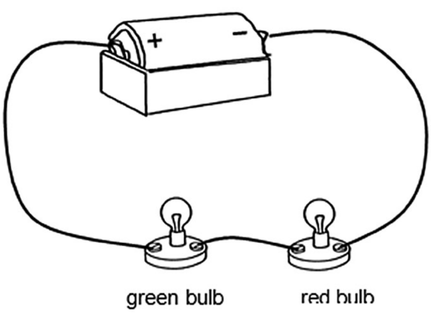
Tymms, 2011). The questions in this research were answered by over 1000 secondary school students; for this question, only 21% of the sample correctly selected **C**. The most attractive choices were **A** (31%) and **B** (30%). Using this question would reveal to the teacher that, although students may talk about a solid made of particles, the idea of empty space (nothing) between the particles is challenging. Those choosing air (**A**) want 'something' to be there and are not thinking that air is also particulate. 'Solid' copper (**B**) is consistent with a model of particles being embedded in the continuous substance.

Another project that has informed the development of the questions and tasks in *York Science* is the EPSE (Evidence-based Practice in Science Education) project (Millar *et al*., 2002). The question in Figure 3 from the Electric Circuits topic will give teachers information about students' understanding of electric circuits. Asking

1 In this circuit, the red bulb is **bright** and the green bulb is **dim**.



Peter decides to swap the two bulbs over, like this:



How bright will the bulbs be now?

A Same as before. The red bulb is bright. The green bulb is dim.

B They change over. The red bulb is now dim. The green bulb is bright.

C Both bulbs are now bright.

D Both bulbs are now dim.

Explain your answer:

....

....

....

Figure 3 Diagnostic question to explore students' understanding of electric circuits students to work in small groups to decide on an answer and explanation will give the teacher an opportunity to eavesdrop on the discussion and find out about the students' thinking.

Questions such as these are written using research evidence about students' understanding; there are many such questions in the *York Science* resources. They are useful at the beginning of a sequence of teaching to find out where learners are in their understanding, or to check on progress during a lesson.

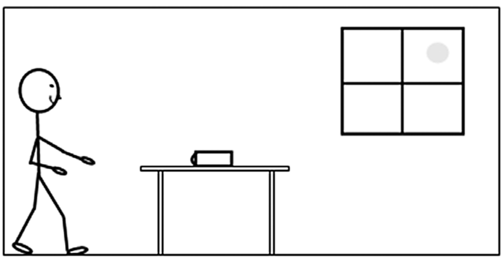
We would agree with Dylan Wiliam's (2011: 79) statement:

I suggest there are only two good reasons to ask questions in class: to cause thinking and to provide information for the teacher about what to do next.

Writing explanations

A student who understands an idea well can explain it to others. Figure 4 shows a task where students have to choose the correct statements

Imagine you are in a room lit by sunlight and you are looking at a book on the table.



Some of the statements in the boxes below link together to form an explanation of how you see the book.

Some rows contain more than one statement. In each of these rows, pick the statement that you think is **correct and fits into the whole explanation.** Indicate your choice by drawing a ring around it.

Continue until you have chosen one statement from every box. Link the statements with arrows to show a complete scientific explanation for how you see the book.

1	Light travels out in all directions from the Sun.

2	Sunlight passes through the window into the room.

3a Some of this light from the Sun falls on the book.	3b Some of this light from the Sun goes into my eyes.	3c Sunlight fills the room and makes it bright.

4a Light is emitted by the book.	4b Light is scattered by the book.	4c Light is absorbed by the book.

5a As a result, some light travels from the book to my eyes.	5b At the same time, some light goes from my eyes to the book.

6a I see the book because it is lit up.	6b I see the book because this light enters my eyes.

Figure 4 Diagnostic question to explore students' understanding of the 'passive eye' model of vision

to construct an explanation of how we see. The incorrect statements are based on statements made by students trying to explain how we see to researchers (Guesne, 1985).

This style of question can be used for a variety of explanations that students might be expected to give. It would be easy for a teacher to see who had the correct explanation by the pattern of the arrows on the page.

Backward design

This approach to designing a course, a teaching module or a lesson has been described as reverse engineering or 'backward design'. It can be summarised thus:

- begin by writing a set of questions and tasks that would provide you with evidence that a student had (or had not) achieved each of the learning intentions;
- only then start to plan activities and a teaching sequence to help students learn what they need to learn to do such questions and tasks.

There will be a full article about the backward design approach in the March 2014 issue of *School Science Review*.

Teachers and others have reacted very positively to the approach; indeed, after hearing about the project at the January 2013 ASE Annual Conference a local authority adviser wrote that:

the key strength of the approach is that it puts assessment for learning right at the heart of the planning process and therefore at the heart of the teaching.

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York Science: www.yorkscience.org.uk.

Mary Whitehouse is a member of the University of York Science Education Group and is joint Project Director for *Twenty First Century Science* and for *York Science*.
twitter.com/MaryUYSEG. Email: mary.whitehouse@york.ac.uk