Activity Q

Teaching Ideas and Evidence through 'The Solar System' in Year 7

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The Project

This research project involved a year 7 class of mixed attainment. Using the Cambridge Curriculum Model of the Nature of Science (Taber, 2004) as a guide, I created my own 'pupil-friendly' curriculum model, and created a worksheet that I used to probe the pupils' prior understanding of the nature of science (appendix 1). From this probe it was clear that pupils' understanding of the scientific model matched least closely with the curriculum model definition, and so I chose to focus on teaching the concept of a scientific model. Over the course of two lessons, this concept was taught through the topic of the Solar System.

Prior to the first lesson, I probed pupils' prior knowledge about the Solar System (appendix 2). This revealed that most had a good understanding of the topics taught at Key Stage 2. I therefore used the first lesson to consolidate learning for some pupils, and apply the idea of scientific models to the concepts with which other pupils were confident. I began the first lesson by defining a scientific model, and then used a series of 'models' relating to the concept of day and night (appendix 3). For each model I asked pupils to explain (either verbally or in writing), first, what the model was, second, what it showed, third, what its limitations were, and fourth, how it could be improved to make it more realistic. I then asked pupils to come up with their own models to explain why we get different seasons, and to assess the strengths and weaknesses of the suggested models. I also asked if they could improve the suggested model to make it more realistic.
During lesson 2 I combined teaching about why we have different seasons with reinforcing learning about scientific models. I showed pupils two models to explain the seasons and asked them to evaluate them. I used a worksheet during the lesson to support learning of the content and a consolidation worksheet for homework to ensure all pupils had understood the lesson.

Rationale

The teaching was intended to familiarise pupils with the concept of a scientific model, and to enable them to critically evaluate models that are commonly used, as well as suggesting and critically evaluating their own models. Pupils were also encouraged to suggest improvement to existing models, and explain why it is necessary to use models that are not perfect representations of the systems that they are designed to explain. The activities were designed to challenge all pupils in a mixed attainment class, with the more able/gifted and talented pupils exercising higher level thinking, and criticising more thoroughly the existing models. Higher attaining pupils were also able to suggest their

own models, while the others were able to consider the advantages and disadvantages of the models. Since teaching was focused on the concepts with which pupils were already familiar from Key Stage 2, understanding was not a barrier to the consideration of scientific models, and this also provided an opportunity to consolidate the content with the lower attaining pupils.

Evaluation

Some pupils found it very difficult during lesson one to overcome the idea that a model is a physical scale-version of a physical object or set of objects. For example, after considering the first model of day and night shown during the first lesson, pupils were asked 'What is the model?' The majority of pupils thought that it was a plastic globe. However, after talking about different types of model, most pupils refined their understanding. Generally, the work of the high attaining pupils revealed a sound understanding of the concept of a model. Only one such pupil connected the model of the Earth rotating round the Sun with the seasons (applying his knowledge of why the seasons occur to a model that does not directly reveal anything about the seasons). It is unclear whether or not he thought that the model showed that it takes 365.25 days for the Earth to orbit the Sun or whether he was simply giving information that he already knew. A low attaining pupil gave a reasonably good response to the task, although his response was affected by his poor literacy skills. He had clearly understood what the model was and been able to point out its limitations and suggest improvements. Responses from average-attaining pupils showed that they had a sound understanding of what a model was, and they were able to point out the strengths and weaknesses of the model, but their answers were briefer than those of the high-attaining pupils.

When asked to suggest a model for why we get different seasons (based only on their knowledge from Key Stage 2), two pupils put forward suggestions. One low attaining girl suggested that four coloured objects placed randomly in the room could represent each season (yellow = summer, dark green = spring, grey/green = autumn, white = winter). The pupils were able to point out several disadvantages of this model, but restricted their description of its strengths to a discussion about how easy it was to understand (having no words). Another high attaining boy then suggested a refinement to the model. He put one person in the centre of the room (the Sun), and another person walking around them (the Earth), at a slight tilt. This person had the four different colours attached to different parts of his body to illustrate that the seasons were linked to the orbiting of the Earth round the Sun.

Outcomes

I believe that the pupils benefited from this teaching. It increased their scientific vocabulary (the word 'model' was used extensively) and it introduced them to another way of thinking about science, critically analysing the work of others rather than blindly accepting facts without evidence. Many of the pupils also developed the ability to accept a model despite its obvious limitations. Often, the more realistic a model becomes, the more complicated it is to understand.

The teaching also allowed me to develop my own model of teaching about how the nature of science, and gave me an opportunity to experience teaching part of scientific enquiry part of the National Curriculum for Science.

Recommendations:

I think that ideas about the nature of science should ideally be taught early in Key Stage 3, equipping pupils with a vocabulary and understanding to help them to get the most out of their learning in other areas of the science curriculum. I have found that pupils of all levels of attainment in Key Stage 3 are able to understand the nature of a scientific model. I also found that it took much longer than expected for pupils to overcome their preconceived ideas about models. So, while teaching about models should be embedded in the teaching of subject content, more time will be needed to address both aspects of science. Since this particular aspect of the nature of science is conceptually demanding, it is likely to be advantageous to teach it at the beginning of a topic of which the pupils already have some understanding, so that their subject knowledge does not inhibit their ability to criticise models.

References:

Taber, K. 2004. The Nature of Science – a model. (Available on the CDROM)

Appendix 1: A probe of pupils' prior understanding of the nature of science

???? What is Science all About? ????

You have been studying science since primary school, so you should now have some idea of what science is all about. Here is a list of words that are extremely important in science and scientific discovery.

Please explain the scientific meaning of each word in as much detail as you can. Use any examples you can think of.

1. Theory

2. Observation

3. Experiment

4. Evidence

5. Model

Make sure that you have given a scientific meaning for each word. **If you're not sure, still write down your ideas.** Try to give at least one example for each word. Think about work that you have done in science or things that **famous** scientists know about.

Appendix 2: Assessing pupils' prior knowledge about the solar system

The Solar System Quiz

Try to answer all of the questions even if you are not sure that your idea is right. If you need more space for your answer to any question, use the other side of the sheet.

1. What shape are the Earth and the other planets? _____

2. a) Which is smallest: the Sun, the Earth or the Moon? _____

   b) Which is biggest? _____

3. a) Does the Sun move around the Earth? _____

   b) How do we know? What is the evidence? _____

_____

4. How long does the Moon take to go around the Earth once? _____

5. Why do we have 24 hours in a day? _____

_____

6. Why does the Moon appear to change shape at different times of each month?

_____

_____

7. At what time of day would you expect shadows to be shortest, and why?

_____

_____

8. In Britain, why is it colder in winter than in summer? _____

_____

9. Draw and label a picture of the Solar System (including the Sun and the planets). It does not matter how good at drawing you are.

Modelling Day and Night

Pupils should already know that the sun, moon and planets are approximately spherical but may need reminding that they are not 'circular' or 'round'. They should also have an idea of the relative size of the Sun, Moon and Earth, and know that the Earth orbits the Sun.

The *ideas and evidence* focus of this lesson will be on introducing the concept of **scientific models**.

Possible Teaching Activities	**Learning Outcomes**
• Prior knowledge test to see what pupils know from KS2 and highlight misconceptions (if possible, this should be done prior to lesson 1 of this module) • Explain what we mean by a scientific 'model' (give written definition) and that models have limitations. • Turn lights out and shut blinds. Show rotating (East-West) globe with slide projector light source (far enough away that the whole globe is illuminated from one side). Ask pupils what the model is showing, what it does not show and how it could be improved (a written activity). Draw attention to the tilted axis of the Earth. • Remove globe. Ask pupils to use their hands as 'blinkers' and tell them they're looking into the sky from Earth. They should rotate their heads until they see the light source, and continue until it disappears again. Ask what this model is showing (apparent movement of the sun across the sky). Limitations include that sun's path is curved. Use analogy of trees whizzing past a train (explain this is a model too). • Ask pupils to suggest their own models, for example for the seasons. Ask the class to point out the strengths and weaknesses of these models, and to suggest improvements to the models to make them more realistic.	All pupils will be able: • to explain what a model is. • to identify the strengths and weaknesses of solar system models. Most pupils will be able: • to use models to explain why we have day and night. • to explain why the sun appears to move across the sky. Some pupils will be able: • to suggest their own models, for instance to explain why we have different seasons.

Resources: Globe, slide projector.

Safety: Remind pupils never to look directly at the sun.

Seasons

The ideas and evidence focus of this lesson will be on reinforcing the concept of **scientific models**.

Possible Teaching Activities	Learning Outcomes
• Ask pupils what they remember a model to be. • Model the passing of a year by orbiting a globe around a light source. Discuss why we have leap years (pupils may already know). • Use the same model to explain why we have different seasons, by looking carefully at the angle of the Earth's tilt in relation to the Sun. This is difficult to understand using this model; suggest that we *improve the model.* • Use infra-red lamp and IR detector pointed towards the Earth to model how that the Equator is warmer than the poles, and that it is warmer in Britain when the axis points towards the sun (summer) than when it points away from the sun (winter). • Ask pupils to explain in writing why it is easier to understand why we get different seasons when modelling it using an infra-red lamp and IR detector than when modelling the system using a normal light bulb. • Use diagrams of the sun's rays hitting the Earth to explain seasons in terms of concentration of the energy from the sun. • Complete 'The Seasons' sheet	All pupils will be able: • To continue to identify the strengths and weaknesses of solar system models • to explain why we have different seasons, in terms of the position of the Earth in its orbit. • to identify the Sun and Earth from diagrams of the Earth's orbit. Most pupils will be able: • to compare two models in terms of how well they help us to understand the seasons. Some pupils will be able: • to explain why we have different seasons in terms of the concentration of energy from the Sun's rays

Resources: Worksheets: 'The Seasons' and 'The Earth and the Sun', globe, slide projector, free-standing light bulb, infra-red lamp, IR detector.

Safety: Remind pupils never to look directly at the sun.