Minibooster 3: Progressing to level 6 and beyond

What do we mean by evidence?

Background

The following points need to be made explicit to pupils:

- evidence is the outcome from measurements (e.g. most often as data in tables, or represented as graphs) and observations
- We use evidence to:
    - support or challenge an idea, prediction, theory or model;
    - make links;
    - identify differences;
    - decide whether something is changing over time;
    - raise questions for further investigation.

A pupil working at:

Level 4

- can suggest what to collect as evidence to challenge or support an idea, prediction, theory, hypothesis or model;
- can decide if they have enough readings to make a judgement about pattern or cause and effect.

Level 5

- is able to discriminate between relevant and irrelevant evidence;
- is able to distinguish between fact and opinion;
- decides whether the evidence found was sufficiently accurate;
- decides whether the evidence found was sufficiently reliable;
- decides whether the evidence is secure because an appropriate range for the variable was selected;
- decides whether the evidence is secure because the sample size investigated was appropriate;
- explains why the secondary evidence is in/sufficient to support the conclusion or interpretation made.

00054-2008DVD-EN

Level 6

- can decide from a variety of evidence which is most valid for making a judgement about the original idea;
- can use evidence to raise further questions;
- records data and features effectively, choosing scales for graphs and diagrams;
- analyses findings to draw conclusions that are consistent with the evidence and uses scientific knowledge and understanding to explain them, accounting for any inconsistencies in the evidence;
- evaluates evidence, making reasoned suggestions about how their working methods could be improved;
- explains why the secondary evidence is in/sufficient to support the conclusion or interpretation made and any implications arising;
- explains how the evidence from the results links to the conclusions drawn and whether it is sufficient.

Level 7

- can explain how they made judgements based on conflicting evidence;
- can use evidence to extend the original idea and to raise further questions or predictions;
- analyses findings to draw conclusions that are consistent with the evidence and uses scientific knowledge and understanding to explain these conclusions and identify possible limitations in primary and secondary data;
- explains, using scientific knowledge and understanding, how some of the limitations in the secondary evidence can distort the conclusion drawn;
- recognises that scientific controversies can arise from different ways of interpreting evidence.

To move pupils from level 4 to level 5

1. Illustrate how to make sensible decisions about what evidence to collect.
2. Guide pupils to decide if something is evidence or just true but not helpful.
3. Help pupils to distinguish between fact and opinion.

00054-2008DVD-EN

To move pupils from level 5 to level 6+

1. Provide pupils with sources of evidence and ask them to suggest what ideas are being tested.
2. Give pupils a variety of sources of evidence and ask them to explain which is most valid to support or challenge the original idea.
3. Encourage pupils to raise further questions to extend the original idea.
4. Give pupils opportunities to discuss, reflect, justify and explain the thinking behind their judgements.

Activities

Many of the activities in the suggested teaching sequence in Minibooster 3: *What do we mean by evidence – Science intervention materials* DfES 0077 2004 are appropriate for moving pupils from level 5 to level 6+ with minor adaptations. These original activities are included in this Minibooster.

Activity 1

Use Worksheets 3(i), 3(ii) and 3(iii). Worksheet 3(i) '*Is this evidence?*' could be used as a starting point activity to check that pupils are secure at levels 4/5. Three or four questions should be sufficient.

When using Worksheet 3(ii) '*What evidence do I need?*' ask pupils to include the ranges and intervals of the variables and to explain **why** they have made those decisions.

Worksheet 3(iii) '*The right evidence?*' could be adapted for level 6+ by using it in reverse: give pupils the evidence statement and ask them to suggest which idea was being tested. Pupils could then compare the intended idea with theirs, and discuss the appropriateness of the source of evidence suggested. They could then reflect on limitations that might arise from any practical difficulties in gathering the evidence.

00054-2008DVD-EN

Activity 2

Use Worksheet 3(iv) *'Getting useful evidence'*.

This will consolidate pupils' understanding of whether the evidence is useful or sufficient.

Activity 3

Use worksheet 3(v) '*Which statements support the view that the Earth is round and not flat?*'

This contains activities suitable for level 6+.

The activity could be extended by asking pupils to generate further examples of statements that are true but might or might not support the idea. Ask pupils to discuss how they made the decision and how much they had to infer from the statement.

Activity 4

Use worksheet 3 (vi) '*Fact or opinion?*'

This sheet could be extended to level 6+ by asking pupils to consider the following.

- What difference does it make to the meaning of the article if opinions are removed?
- Is there any conflicting evidence in the article?
- Is actual data presented, or someone's inference from the data?
- Is the information given relevant?
- What further information do they need?

In addition

The Upd8 material available on the ASE website has been considerably enhanced and a section called SciQ has been added. Many lesson ideas and resources can be accessed by clicking on 'Finder' and 'Topics', and can be downloaded.

The following resources are suitable for extending pupils' thinking and understanding about what we mean by evidence.

- *Shampoo Claims –Truth or Lies?* A hair shampoo advert claiming to make hair 10% stronger has been banned by the Advertising Standards Authority (ASA). There was, says the ASA, insufficient

00054-2008DVD-EN

scientific evidence to support the claim. This activity asks pupils to evaluate data from trials of hair strength, and to decide what the data shows (if anything!). They then examine other advertisers' claims.

- *Is life a dream?* There is something odd about our universe. It is just too perfect! Everything about it seems tailor-made to make sure that humans would evolve. Could an advanced civilisation have 'fixed it' for us? Might we be 'The Sims' in a mammoth simulation? Some top scientists think it is a serious possibility. Are they right? We may never know. In this discussion activity, pupils rate the arguments for and against this controversial idea.
- *Ricin*. Ricin is one of the most deadly poisons known – it is 12 000 times more toxic than rattlesnake venom – and there is no antidote. It is most famous for its role in the 1978 'umbrella assassination'. Bulgarian dissident Georgi Markov had been waiting for a bus when he felt something sharp jab him in the leg. Three days later he was dead. A specially adapted umbrella had been used to push a pellet of poison beneath his skin. As the wound reddened, a lethal dose of ricin was leaking into Markov's blood. The assassin's identity has long been a mystery. But now he can be brought to trial. In this activity, pupils prepare a brief on ricin for the prosecution barrister.
- *Isotope kills ex-spy*. Alexander Litvinenko, a former soviet spy, knew he had enemies. When a mystery illness struck, he assumed he had been poisoned. But what with? Any number of toxins could account for his symptoms – food poisoning, thallium, a radioactive isotope. As new data accumulated, the investigators' conclusions were forced to change. Nothing like this had been seen before. It took 3 weeks to identify the polonnium-210 he had ingested, and by then he was dead. In this activity pupils research polonium-210 and explain how it killed Litvinenko.

Resources on *Fact or Fiction?* are readily available by typing that question into any Internet search engine.

Suggested teaching sequence

The following activities could all be done in one lesson or divided into separate activities and spread over more than one lesson.

1. **To teach pupils to make sensible decisions about what evidence to collect**

- Discuss with pupils what evidence scientists need and where they get it from. Use Worksheet 3(i) '*Is this evidence?*' to prompt discussion.

00054-2008DVD-EN

- Use the exercise on Worksheet 3(ii) '*What evidence do I need?*' Pupils they have to decide what they could measure or observe to provide the evidence for the investigation. The activity could be done in small groups and answers written on the sheet, or the investigations could be used on an interactive whiteboard or with a digital data projector and discussed one at a time in small groups. Other investigations that pupils are more familiar with could be used. In each case, collect answers from each group and discuss differences of opinion across the whole class. Ask the following types of question.
    - Were some investigations easier to decide about than others?
    - What made some easier to decide?
    - What helped you to decide what to measure or observe?
    - Were there any clues in the title of the investigation?
    - Did you feel you needed more information to help you?
    - What sort of information do you think would be helpful?

- Give pupils Worksheet 3(iii) '*The right evidence?*' Pupils discuss whether the pupils in each example were collecting the right evidence. These examples could be given as a printed sheet, on an interactive whiteboard or with a digital data projector. In each case, collect feedback from groups, and host a whole-class discussion, especially if there is a difference of opinion. You could ask the following types of question.
    - What helped you to decide whether the pupils were collecting the right or wrong evidence?
    - If you do not think they were collecting the right evidence, what would you suggest that they do?
    - Why do you think they might have picked the wrong thing to measure or observe?
    - Could the pupils have collected other evidence that would have been just as useful?

2. **To teach pupils how to decide if they have sufficient data or a suitable range of data**

- If you are looking at evidence for fair tests not involving living things, use *AKSIS Investigations: developing understanding in scientific enquiry*, pp. 50–55. Available from the ASE ISBN 086-357-310X.
- If you are looking for evidence for fair tests or pattern seeking with living things, use *AKSIS Investigations: developing understanding in scientific enquiry*, pp. 55–62.

00054-2008DVD-EN

- You can use the above activities to create some prompts for pupils to consider when they are planning to collect evidence, or use worksheet 3(iv) '*Getting useful evidence*'. Pupils can then review their own investigations (or copy some from other classes if that is less threatening) and consider whether the evidence they collected was useful.

3. **To teach pupils how to decide if something is evidence or just 'true but not helpful'**

- Use the evidence cards from the *Scientific enquiry* unit on smoking (task J, page 101) (*Scientific enquiry: resources for participants*, DfES 0391/2002).
- Use Worksheet 3(v) '*Which statements support the view that the Earth is spherical?*'
- Use the Upd8 material from the ASE website (www.ase.org.uk), for example, *Global warming* – use the cards to decide if the statements are evidence for global warming; *Shuttle disaster* – read this and highlight statements that are true but are not evidence for the disaster.

4. **To teach pupils to begin to distinguish between fact and opinion**

- Discuss with pupils the difference between fact and opinion (i.e. facts are backed up by evidence). For example, many pupils think that evolution is a fact when it is a theory. Facts and opinions are often intermingled in books to try to make a text more accessible.
- Use Worksheet 3(vi) '*Fact or opinion?*' with pupils. This article is taken from Upd8, available on the ASE website. The site has further articles which could be used in the same way, or use Worksheet 3(vii) '*Are mobile phones dangerous?*' to encourage pupils to decide if the information given is fact or opinion, and to explain why.

00054-2008DVD-EN

Worksheet 3(i)

Is this evidence?

- An experiment carried out by a famous scientist
- A table of results
- What my dad said when I asked him
- A graph
- An experiment carried out by me
- A newspaper article
- An interview with a professor on the radio
- What is written in my science textbook
- What my teacher told me
- What I found on the Internet
- A survey I did in school
- What my best friend told me
- A science-based television programme

00054-2008DVD-EN

Worksheet 3(ii)

What evidence do I need?

In your group, read each question to investigate and decide what could be measured or observed to provide evidence to answer the question.

Question to investigate	***What could I measure or observe to provide the evidence to help answer the question?***
Will the temperature of the water make a difference to how much salt dissolves?	
What happens when acid is added to different metals?	
Which type of sugar is best for pollen tube growth?	
Will the number of coils of wire make a difference to the strength of an electromagnet?	
Does hearing range decrease with age?	
Which is the best fuel to burn?	
What conditions do woodlice prefer?	
Does the number of layers of insulation affect how quickly water cools down?	

00054-2008DVD-EN

Worksheet 3(iii)

The right evidence?

1. Pupils wanted to find out if people with the longest arms can throw a bean bag the furthest.

   They measured the length of people's arms and how heavy the bean bag was.

2. Pupils wanted to find out how much water there is in an apple.

   They timed how long it took for the apple to cook.

3. Pupils wanted to see whether different soils soaked up (absorbed) the same amount of water.

   They used the same amount of water each time and measured how much water dripped through the soil.

4. Pupils wanted to find out whether different coloured objects were the same colour when they looked at them in beams of different-coloured light.

   They drew what the object looked like in each light beam and coloured it in.

5. Pupils wanted to find out if more dandelions grew on rough ground than on the school field.

   They counted the number of leaves each dandelion had. They looked to see if the dandelions on rough ground had more leaves.

6. Pupils wanted to know if sugar made yeast grow faster.

   They measured the height of froth on the yeast after 30 minutes.

7. Pupils wanted to find out if plants grew faster when they were given fertiliser.

   They tested a leaf from each plant to see if it contained starch.

8. Pupils wanted to find out if acids affected metals.

   They measured the pH of the acid to see if it was nearer to pH 1 or to pH 7.

00054-2008DVD-EN

Worksheet 3(iv)

Getting useful evidence

Some questions to ask when planning what evidence to collect during scientific enquiry, including investigations

For a fair test investigation (but not with living things)

- Have I got enough values to show a pattern?
- Are the values spread out enough to show a difference?
- Are the values going up in equal steps to make it easier to see a pattern?
- Are there any values that are not helpful?

For investigations with living things

- Is my sample size too small?
- Is my sample size too big because it will take too long to collect the evidence?
- Am I taking my samples from different places?
- Am I taking my samples fairly?

00054-2008DVD-EN

Worksheet 3(v)

Which statements support the view that the Earth is round and not flat

Read each statement and decide whether it is evidence which helps or does not help to decide whether the Earth is round.

When ships sail towards you, the mast appears first.	The Earth has a magnetic field.
The Earth looks round when viewed from space.	If you travel west you get back to where you started.
The Sun travels across the sky in the same direction every day.	The Earth takes a year to travel round the Sun.
Globes are round.	The Moon and the Sun look round.
People don't fall off the Earth when they travel a long distance.	The Earth spins round on its axis.

00054-2008DVD-EN

Worksheet 3(vi)

Fact or opinion?

Highlight in yellow any statements that are facts.

Highlight in red any statements that are opinion.

The last bananas

Bananas are under threat from a deadly fungus called Black Sigatoka, which damages the fruit and kills the plants within a couple of years. The banana industry could die out completely within 10 years.

All types of fruits are attacked by pests and disease. But most plants have a weapon – sexual reproduction. This gives rise to new combinations of genes and sometimes mutations that can protect the plant against invaders. The banana is different. It has no male or female sex cells so produces no seeds, and so does not reproduce sexually. It therefore has no method of evolving ways to resist disease.

How do we get new banana plants? By taking cuttings from the stems of the old plant and replanting them. All the bananas you eat are genetically identical. Some varieties of banana can reproduce sexually. But they have hard seeds and are unpleasant to eat. It is the ‘mutant bananas’, with delicious fruit but no seeds, that people have enjoyed since the Stone Age.

To fight the fungus, growers have been spraying banana plants up to 40 times a year. But the chemicals cause problems. In Costa Rica, one-fifth of male banana workers are now sterile.

00054-2008DVD-EN

Worksheet 3 (vii)

Are mobile phones dangerous?

The statements below provide a case against the use of mobile phones (Yes) and support the use of mobile phones (No). Decide which statements are fact and which are fiction.

Yes	*No*
Radiofrequency waves given off by mobile phones can heat up body tissue, having damaging effects.	Radiofrequency waves are not powerful enough to cause heat damage to the body.
Magnetic fields created by mobile phones can affect the way that your body cells work.	The magnetic fields are incredibly small, and so unlikely to affect cells in our body.
People who make long mobile-phone calls sometimes complain of fatigue, headaches and loss of concentration.	The same results have never been reported in laboratory conditions and may be due to other factors in modern lifestyles.
Mobile-phone users are 2.5 times more likely to develop cancer in areas of the brain adjacent to the ear that they use for phone calls.	Researchers admit that it is unclear whether this increase is linked to using mobile phones.
The International Agency for Research on Cancer found a link between childhood cancer and power lines. Like mobile phones, power lines emit radiation.	The radiation produced by power lines is a different kind of radiation, with much more energy than that coming from mobile phones.
Radiofrequency waves similar to those in mobile phones altered worms.	Worms are not humans; there is no guarantee that our brain cells will behave in the same way.

00054-2008DVD-EN