

STUDENT ACTIVITY: Mystery boxes

Activity idea

In this activity, students determine the contents of a 'mystery' box by making observations but without opening it, and parallels are drawn between this activity and aspects of the nature of science.

By the end of this activity, students should be able to:

- distinguish between observations and inferences or interpretations
- illustrate how data can be obtained by making non-visual observations
- explain that scientists pose questions, test and revise hypotheses based on evidence
- recognise that science is uncertain because it is a human activity
- understand that science does not prove or conclude – it is always a work in progress
- demonstrate that science is a collaborative enterprise and that scientific uncertainty can be reduced through collaboration.

Students are unlikely to meet all of the activity objectives at the end of one lesson! They should demonstrate a developing understanding of some of these aspects of the nature of science.

[Introduction/background](#)

[What you need](#)

[What to do](#)

[Extension ideas](#)

Introduction/background

The activity is designed to explicitly teach ideas about the nature of science. It contains no specific science content knowledge. This means that the students can learn about the nature of science without having to try to understand new science content at the same time.

Activities like this could be used as part of a unit on the nature of science or they could be incorporated throughout a science programme.

This particular activity helps to clarify the difference between observation and inference. Science is not the orderly accumulation of knowledge. Rather, science requires imagination and creativity to provide inferential statements about observed phenomena. Observations describe what is seen, while inferences are statements made about observed phenomena from conjecture.

It also allows students to see that observations can be made with non-visual senses (for example, auditory senses as they rattle their boxes to determine its contents) and that observations can be aided by instruments (using a magnet against the side of the box, weighing it, using X-ray and so on.)

Since the students cannot open the box, they can never be 100% certain about its contents. This helps students to see that scientific knowledge is tentative.

What you need

- Identical small boxes (or containers) – one for each group of 3–4 students (a 10 cm cube is a good size)
- Variety of small objects such as nails, paper clips, marbles, cotton buds, table tennis balls, short pencils and so on
- Tape

What to do

1. Before the session, place one item (or a few of one kind of item) into each box. It is a good idea to have 3–4 boxes of the same item(s). Tape each box shut.
2. Hand each group of students their box. Ask them to leave it on their table and use their sense of sight to begin making their observations, not inferences.
 - “It is red” is a valid visual observation.
 - “It is pretty” or “It would make a nice box for a gift of fudge” are inferences.
3. Once the students have shared their visual observations, ask them to make as many observations as they can with all their senses without opening the box. For example, they can feel the box, smell it and shake it to listen to it.
4. Have them share and record their observations. Ask them also to use these observations to make a prediction about what the object(s) inside the box is.
5. As a class, discuss how confident they are about their predictions:
 - If you were scientists, would you be prepared to publish your findings in an academic journal, present them at a prestigious conference or stake your reputation and careers on your findings?
6. Discuss what they could do to be more confident. For each option they offer, draw the analogy to how scientists work.

Here are some possible student responses and comparisons with the work of scientists:

Possible student responses

We could hold a magnet against the side of the box or weigh it or X-ray it.

We could get another box, put what we think it is inside it and then compare them.

We could team up with another group with the same box and compare our findings.

We could swap boxes and get another group to check our results.

We could open up the box.

Analogies to the work of scientists

Scientists can use technology to enhance their observations, but sometimes, the most useful technology may be prohibitive.

Scientists can make models to test.

Scientists can collaborate.

Scientists can replicate the work of others to support or challenge their claims.

This is a clear point of difference because scientists often cannot make direct observation.

For example, they can't:

- cut the Earth or Sun in half
- see inside an atom
- go back in time to see the dinosaurs or the rock formations.

In many cases like these, they must rely on indirect observation and inference.

Extension ideas

This activity can be used to illustrate several tenets of the nature of science.

The tentative nature of scientific knowledge

The students would change their conclusions about their item if they were presented with new evidence – for example, if they initially thought that it was an eraser but then found that it was magnetic, they would have to revise their hypothesis – or different members of their research team might interpret an item's sound differently.

The empirical nature of science

Their investigation was based on empirical observations from which they made interpretations. Their explanations needed to be consistent with the empirical evidence.

The inferential, imaginative and creative nature of science

All their observations required interpretation and inference. They needed to be creative and use their imaginations to make these inferences.

The subjective and theory-laden nature of science

Groups with the same item(s) in their boxes will have:

- made different observations
- interpreted their observations differently
- reached different conclusions.

Each group brought different personalities, experiences and knowledge to this task and that affected their observations and conclusions.

References

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