METEORITE IMPACT!

Applying maths and English skills to a science investigation

Andy Markwick and **Megan Wright** describe a cross-curricular investigation into meteor impacts in the engaging context of craters on the Moon

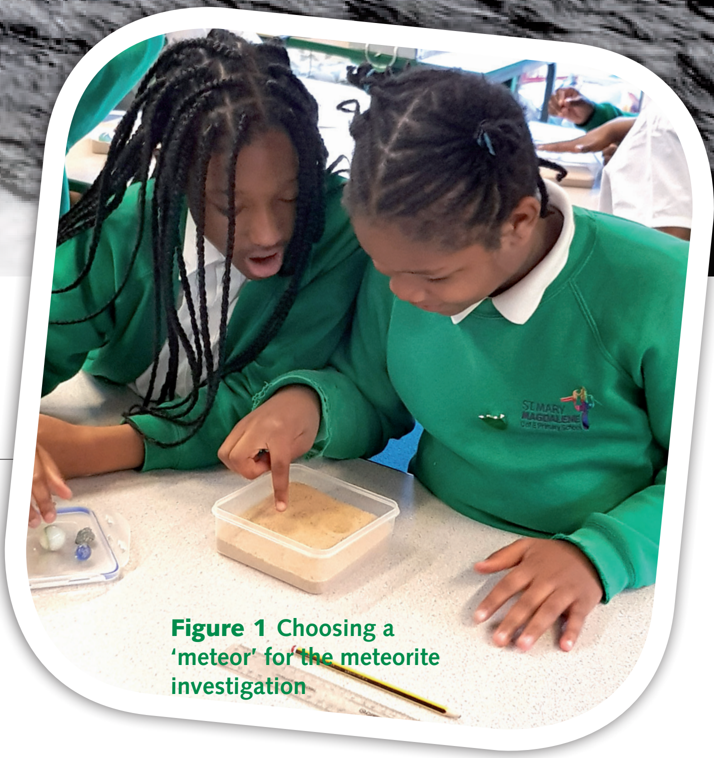

Figure 1 Choosing a 'meteor' for the meteorite investigation

Children's learning is most effective when they are engaged, and this is best achieved within a context that brings science to life. Space is a key area of science that is often taught in year 5 (ages 9–10) in English schools and related to this is gravitational force. Almost without exception children enjoy learning about our solar system and beyond.

This article introduces a series of activities for children to explore the formation of impact craters in the solar system. The activities are designed to provide opportunities for children to apply their mathematics and English knowledge and skills. Children focus their investigation using the fairly familiar context of craters on the Moon. The key learning outcomes for the children are:

- **to be able to describe and then explain their observations of the Moon's surface;**
- **to plan and carry out an investigation into what affects the size of a crater;**
- **to collect, record and display quantitative data;**
- **to apply data to solve a problem.**

The activities support the year 5 and 6 (ages 9–11) National Curriculum in England statements shown in Box 1. They are sequenced to gradually increase challenge and develop deeper understanding, and the application of mathematics and English is made explicit to children throughout.

The following sections outline broadly how the lesson can be conducted in order to address the key learning points with the children, and our experience of implementing it.

Stage 1: Progressing thinking from description to explanation

The Moon's surface

Project an image showing craters on the Moon (copyright-free images can be obtained from https://moon.nasa.gov/galleries/images). Children are asked to suggest what they think the lesson is going to be focused on. This is a quick way to ascertain whether children are familiar with images of

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Box 1 National Curriculum in England statements supported by the activities (DfE, 2013)

Subject	Statements
Science	**Year 5** • Describe the movement of the Earth, and the other planets relative to the Sun. • Describe the movement of the Moon relative to the Earth. • Explain that unsupported objects fall towards the Earth [and Moon] because of the force of gravity.
Mathematics	**Year 5** • Solve problems involving addition, subtraction, multiplication and division and a combination of these, understanding the meaning of the equals sign. • Convert between different units of metric measurement. • Complete, read and interpret information in tables. **Year 6** • Calculate and interpret the mean as an average.
English	**Year 5** • Ask questions to improve their understanding. • Distinguish between statements of fact and opinion. • Provide reasoned justification for their views. • Use organisational and presentational devices to structure text and to guide the reader (for example, headings, bullet points, underlining).

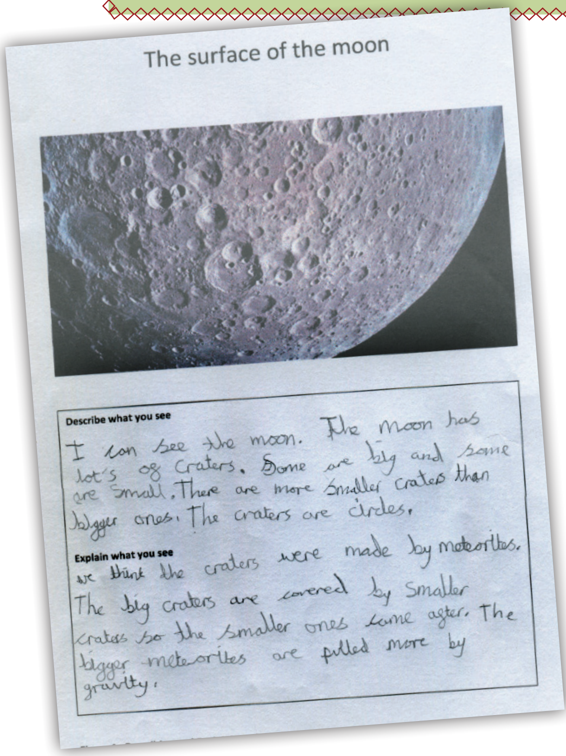


Figure 2 The worksheet focused upon describing and explaining

the Moon and to gauge their general understanding of the topic. It is also a great starting point for discussion.

Give out a worksheet showing the Moon's surface with clearly defined craters (Figure 2). Ask children to spend 3 minutes discussing what they can see. Can they write a description of what the surface of the Moon looks like (remind children that they will need to use adjectives)?

Children often suggest words such as *craters*, *grey*, *smooth*, *bumpy* and *pitted*; further encouragement to describe the shapes of the craters introduced the word *circular* (*round* is incorrect). To further develop children's observational skills, they were asked whether the craters were all circular and whether they were all the same size. Could they explain how the craters were formed? Responses included '*They are all circular, but different sizes*' and '*There's all sizes*'. Children were encouraged to think about how the word *diameter* might be used in their answers, resulting in comments such as '*They all have different diameters*' and '*There are large and small diameters*'.

As an extension, children can be asked to choose a small area of the Moon's surface and count how many craters there are of different sizes, for example, ≤ 0.5 cm, ≥ 0.6 to ≤ 1.0 cm, ≥ 1.0 cm and so on, producing a tally chart (could they use a scale to determine the actual size of the craters?).

Linking descriptions to meteorite impacts and gravity

Ask children to describe what would happen if they jumped into the air. Then ask them to explain why this might happen. They should intuitively know that they would fall back down, and some will know this is because of the Earth's gravity (Box 2).

Ask children to explain why meteors are pulled towards the Moon. Children's responses will demonstrate whether they understand the concept of gravity and whether they use appropriate terminology.

If a meteor hits the surface of the Moon (or the surface of the Earth) we call it a **meteorite**. Ask children to work out which meteorites hit the Moon first, the larger or smaller ones. This problem really challenged the children, yet also promoted good discussion. For example, one child stated '*the smaller craters are on top*', which led to another comment, '*The smaller ones came last. They fell on top of the big ones.*' From a close inspection of the craters in the worksheet picture,

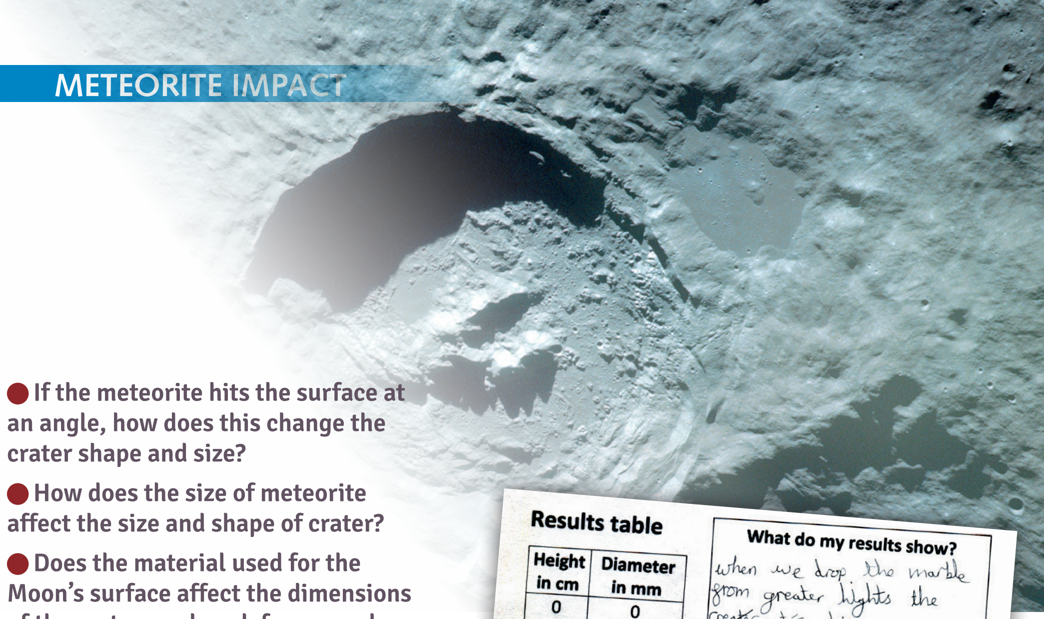
Box 2 Teaching about gravity

Explain that there is a force of attraction between a pen on a table and you, but it is so small you can't feel it. The masses of the pen (~8×10^{-3} kg) and you (~60 kg) are quite small. The Earth has a much larger mass:

~6×10^{24} kg or 6 000 000 000 000 000 000 000 000 kg

and the force between you and the Earth is large; we call this force **gravity**. The Earth's mass pulls you towards it and you pull the Earth towards you! Your weight results from the gravitational force of attraction between your mass and the mass of the Earth.

The Moon also has a gravitational force, but it is only 1/6th that on Earth because its mass is 1/6th of the Earth's mass. Thus, your weight on the Moon would be 1/6th of your weight on Earth! On the Earth, your weight is the force of attraction between your mass and the mass of the Earth. So, what is your weight on the Moon?



it becomes clear that smaller impact craters overlay larger ones. This suggests that the larger meteorite craters are the oldest, that they hit the Moon's surface first.

Children were asked '*Why might this be the case?*' It was interesting to observe how a very active, whole-class discussion ensued. Answers slowly converged on the general agreement that the larger meteors were preferentially attracted towards the Moon because they had larger masses and therefore the gravitational force was greater. It is very likely that both large and small meteorites originate from the same material and area in the solar system. Meteorite dating and compositions are the same, which supports this idea.

An alternative explanation was suggested by the classroom teaching assistant, who thought that the smaller craters might be underneath the larger ones. The response was, '*Then why can't we see any partly covered smaller craters?*' This dialogue sparked a series of discussions among the children, who finally agreed that the evidence suggested the larger craters were formed first, but the possibility that smaller meteorites had hit the Moon's surface first could not be ruled out.

Stage 2: The investigation

How does the drop height of a meteor affect the diameter of the crater formed?

Children were introduced to the model Moon surface (a tub of sand) and meteorites (marbles, rock fragment, etc.) and the measuring equipment (ruler supported in a clampstand) – Figure 3. Crater formation was demonstrated by dropping a marble onto the sand. Three different 'meteors' were provided for each group (one should be an irregular fragment of rock/stone) and the children were asked to find out which meteor formed the best crater. This would be the meteor they use in their investigation.

It is always beneficial to ask children to consider what other variables they might consider investigating. Some potential investigations might include:

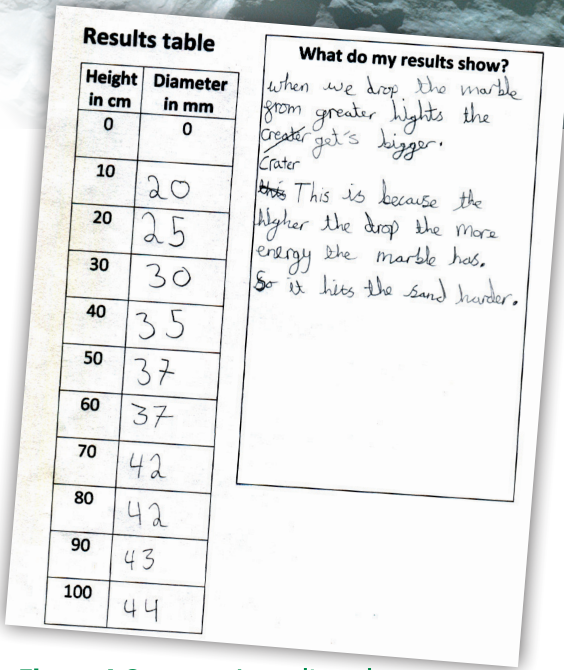
- **How does the shape of the crater vary with meteorite shape? (Children should have noticed that the irregular-shaped rock fragment produced a circular crater.)**
- **What happens to the shape and size of the crater if the surface becomes wet?**
- **If the meteorite hits the surface at an angle, how does this change the crater shape and size?**
- **How does the size of meteorite affect the size and shape of crater?**
- **Does the material used for the Moon's surface affect the dimensions of the crater produced, for example, sand, salt or flour?**

Children may suggest other variables that could be investigated. However, to ensure that children are able to gather quantitative data, plot a graph and discuss its shape so that they can draw a conclusion, the variables in this activity were chosen for them on this occasion.

The drop height was measured in cm and the diameter of the crater in mm. If children measure repeats, crater diameters can be mean averaged, and values recorded to the nearest whole mm.

In our session, time constraints precluded repeating at each drop height and so children recorded only one data point for each drop height (Figure 4). Once all data had been collected and recorded in tables, groups were given 10 minutes to discuss and write about the relationship between meteor drop height and crater diameter. This is an important process as it provides an opportunity for children to consider whether a correlation exists between drop height and crater diameter by interpreting data in their table. The process can be challenging for children, as they need to be able to recognise patterns in data.

Children were then asked whether there might be a better or clearer way to present their data. Although most children suggested a graph as



Results table

Height in cm	Diameter in mm
0	0
10	20
20	25
30	30
40	35
50	37
60	37
70	42
80	42
90	43
100	44

What do my results show?

when we drop the marble from greater hights the ~~creater~~ crater get's bigger.
~~this~~ This is because the higher the drop the more energy the marble has. So it hits the sand harder.

Figure 4 One group's results and interpretation

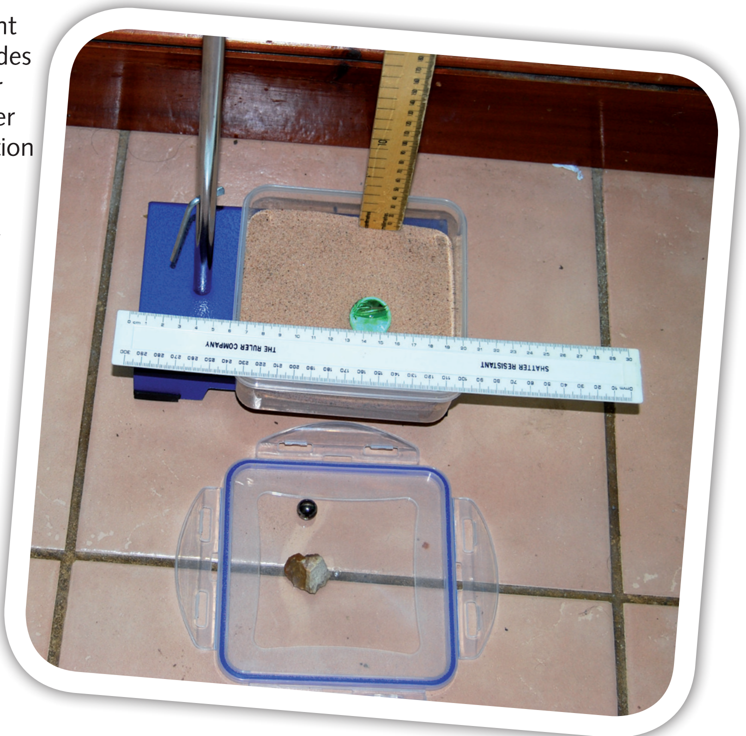


Figure 3 Equipment for the 'meteorite' drop investigation

Box 3 Support in plotting a graph

- **What will each axis be?** It is conventional to plot the variable that is being changed by the experimenter on the *x*-axis (the independent variable). This would be the meteor drop height. The variable that changes as a consequence of what the experimenter is doing is plotted on the *y*-axis (the dependent variable – its value depends on the independent variable's value). This would be the crater diameter.
- **Dividing the axis equally.** The range of values used for each axis needs careful thought. For this set of data the *x*-axis must be divided into equal divisions between 0 cm and 100 cm. The *y*-axis must be divided into equal divisions between 0 mm and 45 mm (or, to simplify, 0 mm and 50 mm). Children will sometimes plot their values directly onto the axes. This misconception can be overcome by demonstrating how axes can be constructed for several different ranges of numbers. Practice is essential!
- **Plotting data points.** It is good practice to model how data points can be plotted on the graph. Usually it only takes a couple of examples before children have the confidence to plot their own data. Children can sometimes want to plot a bar chart rather than a line graph (scatter plot). Scatter diagrams must be used if the variables can take any value (continuous), whereas bar charts are used for plots where values are discrete (discontinuous), such as eye colour, shoe size, etc.
- **A line of best fit.** Once data points have been plotted, a line of best fit can be drawn. Remember in mathematics a line of best fit is a straight line through data points. However, in science we can construct a line of best fit to form a curve if this is what the data points suggest.

the best way to present their data, they required considerable support in constructing them, particularly when defining the ranges for each axis (Box 3).

Stage 3: Interpreting results and concluding

Children were encouraged to look closely at their graphs and asked questions such as '*What shape is your graph?*', '*As the drop height increases, what happens to the diameter of the crater formed?*' and '*If you double the drop height, what happens to the value of the crater diameter?*' Any conclusions drawn by children must be supported by evidence from their own data, either from their table or graph. Most children were able to describe their graph as a curve and to draw a line of best fit (Figure 5).

To probe children's understanding further, questions such as '*Why does a greater drop height produce larger craters?*' were posed. To support children's understanding of this problem the following analogy was used. If you jumped off of a 1 m high wall into a sandpit you would make footprints. What difference would you see in your footprints if you jumped off a 10 m wall into the sandpit?

Most children's explanations tended to focus on the idea that a greater drop height produced impacts with greater energy and so formed larger craters (Figure 4), while a few stated that the higher the meteor drop, the faster it would hit the ground. Challenging children to use both observational and empirical evidence supported their secure understanding of crater formation.

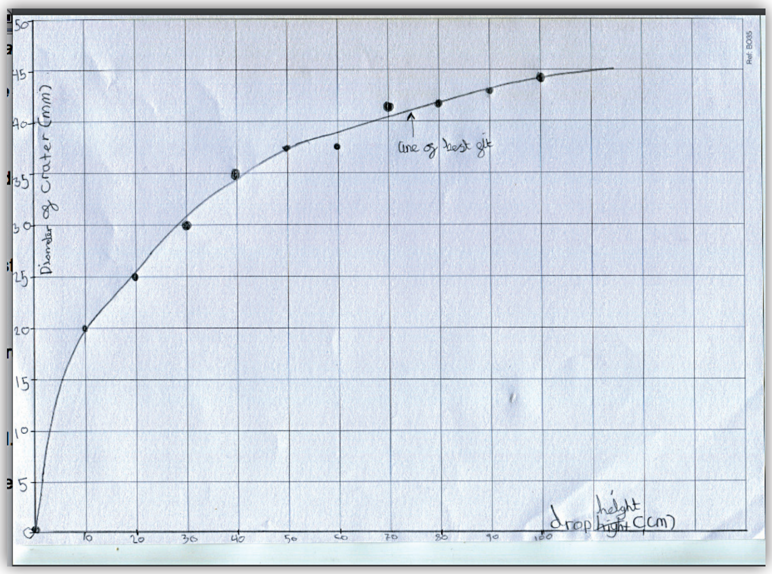


Figure 5 A graph with a line of best fit plotted from the investigation results

Conclusion and further ideas

This series of activities certainly captured children's imaginations and promoted creative and very effective classroom discussion. Solutions to the main science questions emerged from the application of mathematical knowledge and skills and children's ideas and conclusions were confidently communicated by applying core English knowledge and skills, exemplifying a blended approach to learning.

Alongside science, the children's understanding can be deepened through carefully planned cross-curricular links. When studying 'Earth and space', it may be useful to teach a history topic on the Space Race. Children can develop research and communication skills by doing this.

Providing an interesting context such as the 1969 Moon landing can support learning concepts such as gravity. Learning about the key people in space exploration, such as Katherine Johnson (who worked as a NASA mathematician, scientist and computer expert), Helen Sharman (a chemist and the first British astronaut) and Tim Peake (a military person, scientist and the second British astronaut), can be inspirational.

Space, the final frontier, or is it? Let your children decide.

Reference

DfE (2013) *The National Curriculum in England: key stages 1 and 2 framework document.* London: Department for Education.

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