ASTROMATHS EXPLORED!

Claire Seeley and her class explore the universe and broaden their horizons

Figure 1
Modelling day and night

The children at my school, Rendlesham Community Primary School near Woodbridge in Suffolk, have a natural love for, and curiosity about, astronomy. This led to a project full of awe and wonder for my year 5s (ages 9–10) as we delved deeper into the science of the universe.

The study of astronomy is underpinned by some very awesome numbers – something that can both terrify and intrigue adults and children alike! It provides an ideal way for children to meet big numbers, to stretch their concept of number, to build scale models and do some meaningful data handling. Primary-aged children usually only experience a relatively small range of numbers; however, we found that our astronomy project widened their horizons to include numbers they could never before have imagined. Astronomy is often difficult to grasp because of its abstract nature. We worked to make these ideas more concrete and accessible to the children through careful scaffolding of some of the ideas on to things that they already knew about.

The basics

We began our studies by looking at some basic concepts and activities (Box 1). There are lots of areas where misconceptions might arise in astronomy, such as the idea that the Earth's orbit of the Sun means that the Earth is warmer when it is closest to

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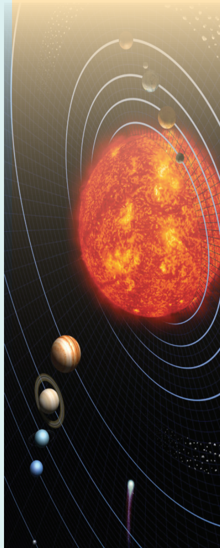
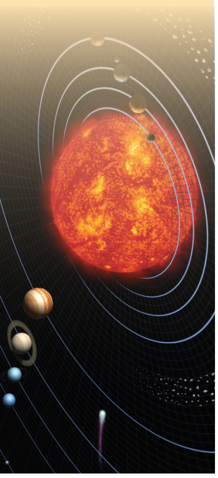


Box 1 Basic astronomy activities

- Make an orrery to show the relationship between the Earth, Sun and Moon.
- Order the planets of the solar system.
- Act out the Earth spinning on its axis or the Moon orbiting the Earth.
- Physical modelling – use balls and torches to show day and night (Figure 1).
- Make a diary of the phases of the Moon each night.
- Make a hat showing the lunar cycle.
- Explore orbiting – swing a ball on a piece of elastic around your head and watch the shape it travels in.
- Explore spinning on an axis – spin a coin on two pins.
- Research Sir Isaac Newton and his apples to discover about gravity.



the Sun. In fact, the seasons arise from the Earth's tilt of 23 degrees. Another common misconception is that the phases of the Moon are caused by the Earth's shadow, rather than the Moon's position in relation to the Sun. It is important to address these misconceptions early on because '*a lack of understanding of the reason for day and night may well have serious repercussions for the comprehension of other ideas in astronomy. … Without a spatial model that properly distinguishes between orbiting and spinning (i.e. revolving and rotating, as many teachers describe it), other systems are nearly impossible to understand*' (Sadler *et al*., 2010).

But the other benefit of studying space as a topic is the many links between the mathematics and science curricula – most notably in the areas of data handling and physical modelling. There are common themes in the two subjects, such as selecting information, recording observations, comparing measurements using tables and bar charts, using these to point out and interpret patterns in data, and relating conclusions to these patterns and to scientific knowledge and understanding.

Concepts of number

We all make up words for really big, indefinite numbers, like gazillion and squillion! These signify a number too large for us to comprehend and there is something fascinating about them. When you look at the planets in the solar system, large, seemingly incomprehensible, numbers begin to gain a context and we have a reason to start to understand them. This proved to be the case with our children, as the space topic provided the stimulus for them to play with really large numbers, to experience them, read them and place them in order (Box 2). The children spent quite a lot of time just learning to read larger numbers, itself an important skill.

Helpfully, these large numbers can be simplified into 'astronomical units' (and I don't mean 'astronomical' as another word for a big number!). An astronomical unit (AU) represents the average distance between the Earth and the Sun, which is 93 million miles. For example, Saturn's average distance from the Sun is 856 million miles. If you express this in astronomical units, it is about 9.5 AU, which not only tells you how far away Saturn is from the Sun, but it also tells you that it is nine and a half times further away from the Sun than Earth is (Box 3). We mainly used astronomical units with the children as they were much easier for them to handle – especially when we made scale models.

Children are fascinated by how far away each planet is from Earth and how long it would take to get there. A good maths investigation, using calculators, is to work out how long it would take to travel to a planet using different modes of transport. These can include, for example, a rocket or the *Virgin Galactic* spaceship, and the children can think about the logistics of space travel to our neighbouring planets. For example, if Mars is 56 million miles away and a rocket can travel at 17,500 mph it would take 3200 hours or 133 days to get there. However, if you travelled by *Virgin Galactic* you would travel at 3000 mph; therefore the journey would take 18,666 hours or 777 days (see *Resources*). From this, questions then arose. What would you need to cope for that long in space? What does space travel do to the human body? The children related their findings to the idea that one day humans might move to habitable planets in other galaxies. They concluded that it would take many generations to travel to them unless someone invents travel at the speed of light!

Box 2 Mathematical terms for big numbers

10,000	= 10^4 = ten thousand
100,000	= 10^5 = a hundred thousand
1,000,000	= 10^6 = a million
10,000,000	= 10^7 = ten million
100,000,000	= 10^8 = a hundred million
1,000,000,000	= 10^9 = a billion

Box 3 Average distance of planets from the Sun in AU

Mercury	0.38
Venus	0.72
Earth	1.00
Mars	1.52
Jupiter	5.20
Saturn	9.54
Uranus	19.22
Neptune	30.06

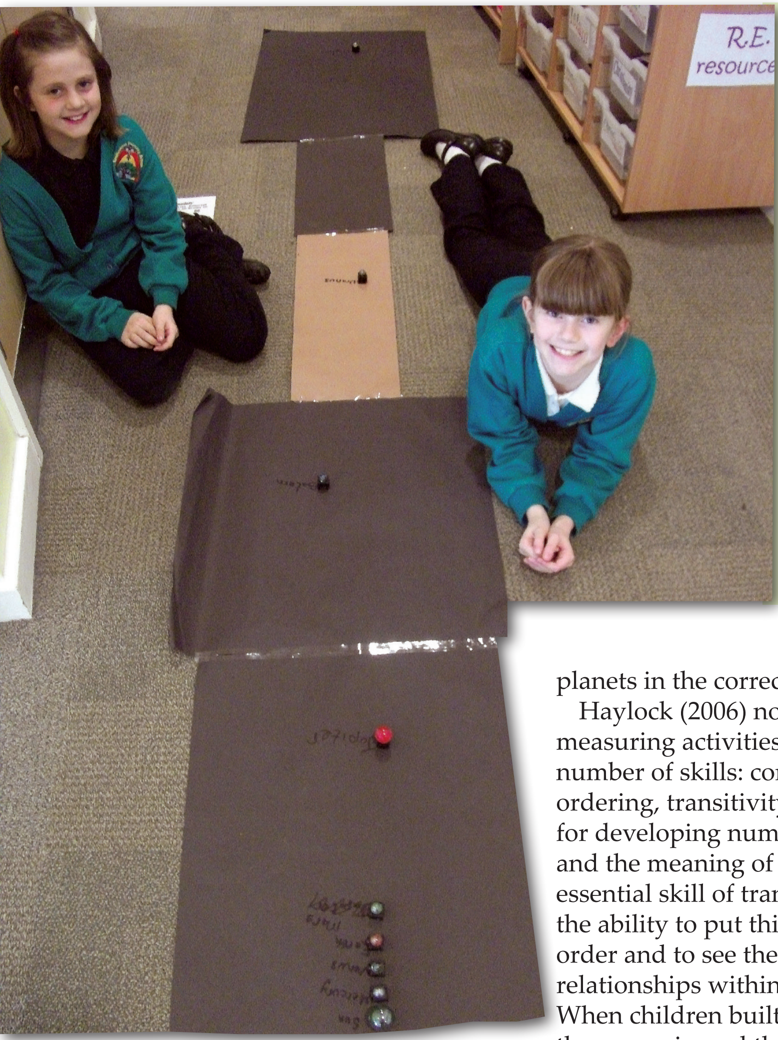


Figure 2 Making scale models of the solar system involved conversion of units, accurate measuring and ordering of numbers

Scale models

Gaining an idea of the scale of the solar system is difficult but it has been expertly demonstrated by Brian Cox in the BBC televison *Stargazing Live* series (see *Resources*):

Understanding our position in the Solar System is one of the great joys of science and is a story that is as old as human civilisation. (Cox, 2011: 71)

We had great fun making a physical model of the solar system. First, we converted the astronomical units into centimetres and then we built our models on the floor with marbles (Figures 2). As the children created their scale models on the floor it threw up all sorts of issues. They needed to remember that each measurement was from the Sun and not from the next planet; they also needed to measure carefully, order the numbers correctly and work methodically in order to place the planets in the correct order.

Haylock (2006) notes that measuring activities involve a number of skills: comparison and ordering, transitivity, a context for developing number concepts and the meaning of zero. The essential skill of transitivity is the ability to put things into order and to see the patterns and relationships within the series. When children built scale models they experienced the relationship between the planets, their relative distances, distribution and patterns in their arrangement. They observed that the gas giants are to be found furthest away from the Sun and they began to ask why this should be.

Negative numbers

The temperatures on the planets dip into negative numbers. In order to get the children to think about these, we made a thermometer showing a variety of places on Earth with extremely low temperatures or very high temperatures, as part of our wider work on 'temperature'. Onto this learning, we scaffolded the idea that, in space, temperatures can be much lower or, indeed, much higher, and we created a solar system thermometer. The children researched further and put the planets into temperature order (Table 1). This led on to looking for patterns and for reasons why a planet is hot or cold, relating this to its position or orbit of the Sun.

Other Ideas

Planispheres (a circular star chart of the constellations) help children to conceptualise the idea that the Earth is spinning as our view of the night sky changes during the night as the Earth turns (see *Resources*). Children can think about how astronomers find their way around the night sky; they make star maps of their favourite constellations using coordinates rather as in the game *Battleships*. However, it is important for children to recognise that the sky is a giant dome and not a flat structure, so on a star map the horizon is the line around the edge of the map and the part in the middle is the sky above their heads.

Data on the planets can be used as a basis for data handling. By representing the data as graphs, Venn and Carroll diagrams, the children start to see more clearly the detailed relationships between the planets. This leads on to a greater understanding of how the solar system works and how it was formed.

Assessment opportunities and inspiration

Looking for the links between science and maths makes for a rich learning experience full

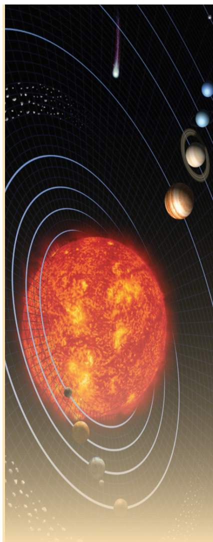


Table 1 Estimated average temperatures of planets within our solar system (from www2.jpl.nasa.gov/basics/Ktable.html)

Planet	Average temperatures/°C
Neptune	–201
Uranus	–197
Saturn	–139
Jupiter	–108
Earth	15
Mars	15 (day)
Venus	362
Mercury	425 (day)

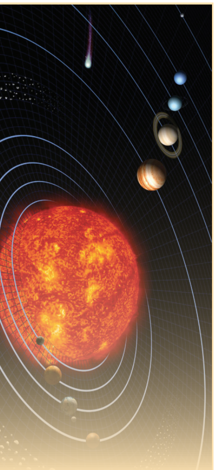


Table 2 Assessment focuses for our Astromaths project based on the English National Curriculum using Assessing Pupils' Progress (APP).

Area for assessment	Maths	Science
Concept of number	Recognise and describe number patterns (MA1, level 4) Use place value to multiply and divide whole numbers by 10 or 100 (MA, level 4)	Select appropriate ways of presenting scientific data (AF3, level 4) Identify patterns in data presented in various formats, including line graphs AND Draw straightforward conclusions from data presented in various formats (AF5. level 4)
Negative numbers	Order negative numbers in context (MA2, level 5)	Identify scientific evidence they have used in drawing conclusions (AF5, level 4)
Data handling	Use Venn and Carroll diagrams to record their sorting and classifying of information (MA4, level 4) Construct simple line graphs and decide upon an appropriate scale for a graph, e.g. labelled divisions representing 2, 5, 10, 100 (MA4, level 4)	
Scale models	Search for a solution by trying out ideas of their own, e.g. identify patterns as they work and form their own generalisations / rules in words (MA1, level 4)	Use simple models to describe scientific ideas (AF1, level 4)
Coordinates and constellations	Begin to rotate a simple shape or object about its centre or a vertex (MA4, level 4)	Describe some simple positive and negative consequences of scientific and technological developments AND Recognise applications of specific scientific ideas (AF2, level 4) Identify aspects of science used within particular jobs or roles (AF2, level 4)

of assessment opportunities, as can be seen from Table 2, which lists the assessment focuses for our project.

Of course, we covered many more things in our project than I can fit into this article. The whole thing was fantastic and possibly led to the most exhilarating time for us all in year 5. I wish you could have seen the higher order learning and thinking that was going on – it was completely joyful!

Resources

National Schools' Observatory: **www.schoolsobservatory.org.uk** – remote access for schools to the Liverpool Telescope and resources for astronomy and space-related activities including planispheres: **www.schoolsobservatory.org.uk/astro/esm/dome22**

Information about the universe: **www.seasky.org**

Faulkes Telescope Project: **www.faulkes-telescope.com**

Bradford Robotic Telescope: **www.schools.telescope.org**

Stargazing Live Scale model of the solar system using fruit: **www.bbc.co.uk/programmes/p00n6zgy**

Information on distances and space travel: **www.wiki.answers.com; www.virgingalactic.com**

APP materials: **webarchive.nationalarchives.gov.uk/20100612050234/nationalstrategies.standards.dcsf.gov.uk/node/20683**

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