The Earth and Space

Observations

The science of astronomy began with observations and it is vital to link this topic to the children's observations. This is important because what we think happens is not always what actually happens and so careful observation often results in surprises. This is particularly true for children who, for example, have been brought up reading story books where the Moon is almost always drawn as a crescent in the night sky. Hence they can be surprised when they observe the various phases of the Moon or see the Moon in the daytime. In science we observe closely and then step back, think and ask the big questions. Why is it like that? How does that happen?

Teaching and learning considerations

The Sun appears to move across the sky during the daytime and eventually the children will need to understand that it is not in fact the Sun moving around us but us moving around the Sun. It is therefore always best to talk about how the Sun *seems* to move.

Owing to light pollution, we are not as familiar with the night sky as our ancestors. In a city there is so much background light that hardly any stars can be seen at night. It is truly awesome to see the multitude of stars in a clear night sky away from street lights. Many young children will not have experienced this so if they go away with the school and there is an opportunity for them to do this, then they will be amazed. Science is all about awe and wonder.

It is very common for children to think that the Moon is only in the sky during the night time. Here is a true story:

A teacher was working with her Key Stage 1 class on this topic and asked them what they thought. All the pupils agreed that 'the Sun is in the sky here in the daytime and the Moon is the night sky in Australia; then they swap so the Sun goes from here to Australia for their day and the Moon comes here for our night'. The next week, the Moon was in the morning sky and the teacher took them to the classroom window to see it. The children were totally bemused that what they had thought was not right – so much so that a few were really worried, and one even asked: 'Are we going to die?'!

So, it is important to find out what children think and then allow them to make observations to test out their ideas.

By definition, it is hard to find linked practical work in this topic so questioning for thinking, pupil discussion, acting and modelling will be key throughout.

Advice:

The primary curriculum has been carefully devised and some things have been very deliberately left until secondary school:

- Primary pupils do not need to understand ***why*** we see the different phases of the Moon and this is quite a tricky concept!

- Primary pupils do not need to understand ***why*** there are different seasons and this is an extremely tricky concept!

Our advice is not to attempt explanations of either of these at primary school.

Teaching approaches: Year 1

- **The seasons and length of day:**

A class chart can be made which is completed on the first day of every term/half term, recording what time the Sun rose and set.
Each time this is filled in, using the times of sunrise and sunset taken from the internet, eg http://www.timeanddate.com/worldclock/sunrise.html
The pupils can then answer the simple questions on the chart
Is it light or dark when you get up in the morning?
Is it light or dark when you have your tea?
Is it light or dark when you go to bed?
They can then discuss the fact that the length of the day varies throughout the year.

- **Weather:**

The weather can be recorded and discussed in numerous ways – it is a British pastime!

Year 5

1. The Sun:

The pupils first make observations and then build on these, moving on to think about *why* these things happen. This is about developing a model.
The model that we hope the children will understand will need to explain:

- Day and night
- The apparent path of the Sun across the sky during the day

The Sun is a star – a star makes its own light and heat. The Sun is one star among very, very many. Like all stars, it generates its heat and light by means of nuclear reactions. The Sun is, in practice, a huge nuclear reactor. Hence it does not need oxygen to burn in space – the answer to the child's question that you will find in the related teaching and learning sequence. It is always important to warn the children not to look directly at the Sun because it is so very bright that it will cause damage to their eyes.

Teaching and learning considerations

Whilst this area of science does not lend itself to practical investigations, it is a wonderful one for making links with scientific ideas from the rest of the curriculum, particularly light. There are certain concepts the pupils need to understand, such as light travelling from a source. We see things around us in the daytime because the light from the Sun reflects off them into our eyes.
The Sun looks like flat disc in the sky but, of course, it is a sphere. It will help pupils to look at a large ball on the other side of the playground to get a feel for the fact that a sphere looks

like a plate or disc from a distance. The Sun looks very placid in the sky, so it is useful for the pupils to see some internet photos that show it to be a very dynamic and explosive object.

Teaching approaches

Observations

Observing the path of the Sun is most easily done by putting a sticker on the classroom windows to show where the Sun is shining in. This is then repeated at regular intervals throughout the day. The pupils will see that the Sun appears to move around the sky in the course of a (sunny!) day.

Another way of doing this is to trace the shadow of the netball post on the playground with chalk at hourly intervals throughout the day. If the shadow is carefully, traced, both the direction and length of the shadow will change during the day.

The pupils could then use a torch and pencil standing upright in a piece of blu-tac to try to model the situation and explain why the shadow changes in the way it does.

Questions

It is a really good idea to let your pupils first think what they want to know about the Earth, Sun and Moon. Put out three large pieces of a paper and write either 'Sun', 'Earth' or 'Moon' on the top of each of them. Give them time to think about this, perhaps overnight, and then ask the pupils write any questions they want answered on the relevant sheet. Do ask them to put their initials next to their questions – this is a very interesting way of uncovering their existing understanding.

Example of an amazing question from a primary pupil who wrote on the 'Sun' sheet:

'How comes the Sun burns in space if there is no oxygen?'

We do not need to worry that we do not know all the answers because we can model the joy of learning together. However, this one is discussed in the physics narrative!

As the topic continues, the pupils can tick off the questions as they are answered. Those that remain unanswered at the end can be researched by the children themselves in their own time or left as intriguing questions for the future.

A series of big questions are ideal to really get the children thinking about the Sun. Using think, pair, share will give them time for deep thinking and also to learn from each other.

Question: What shape is the Sun?

Possible answers might be:

- A yellow circle
- A big yellow ball

Encourage the children to make links between the Sun looking like a flat disc and the fact that it is a sphere. It may help to look at a big plain yellow beach ball that someone holds up on the other side of the playground. It is a sphere but it looks like a disc in the distance.

Big question: It is not safe to stare at the Sun in the sky. Why do you think this is?

It is likely that the children will know not to stare at the Sun but this asks them to consider why it is not a good idea. It is important to keep the emphasis on the 'why?'
The Sun's light is so intense that it can damage our eyes. Show them a close-up picture of the Sun (these are freely available on the internet) and ask them to say what they see. They will be able to see how explosive it is and begin to understand that it is a very, very violent place.

2. The Earth

The history of the development of human understanding in astronomy is just fascinating. The concept of the Earth being a sphere is not at all intuitive and this was a great step forward in our thinking. Then slowly came the understanding that we move in an orbit around the Sun. Hence the Earth is a planet and it gets all its heat and natural light from the Sun. A planet orbits a star – it does not make its own heat and light.

Teaching and learning considerations

Children find the concept of a spherical Earth very tricky. They look out of the window and it looks pretty flat to them! Also if it is sphere, why don't people 'underneath' drop off? These are logical thoughts and questions. Children generally like to believe adults and so it is not uncommon for them to amalgamate their flat Earth model with adults' spherical Earth model.

Teaching approaches

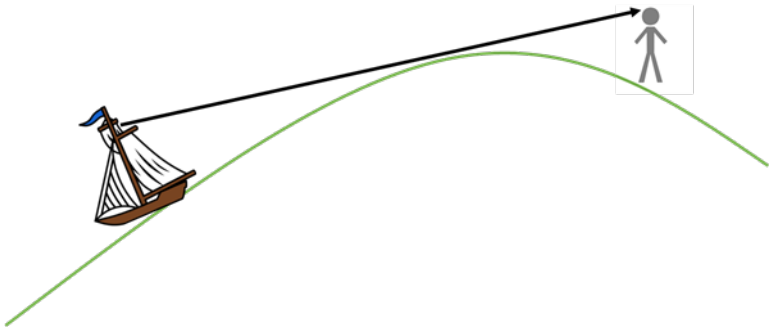
Question: What shape is the Earth?
The children will have seen globes etc so they are likely to know it a sphere. However, a very big question just has to be asked next:
Big Question: How do you know the Earth is a sphere?
(Tell them that they are not allowed pictures from space because they could be forged and the ancient Greek philosophers had worked out that it is sphere, long before space travel.) It is best to ask them to think, pair and share so that they have time to think about this carefully.
The pupils may come up with all sorts of ideas – here are some actual responses from Year 5 pupils:

- 'If it's flat, when you make the foundations for a temple why doesn't it go through?'
- 'Why doesn't water fall off the edge if the Earth is flat?'
- **'**Because gravity comes from the centre of the earth, because a sphere is the smallest shape you can make from the centre, it would most likely be pulled up into a sphere.'

All these answers are good but the last one is awesome and shows very advanced thinking, well beyond most primary pupils. Using big questions in this way is an excellent tool for formative assessment.
The most convincing evidence is something that they might never have seen:

- When a ship appears in the distance, the first thing to be seen is always the top of it.

Tell/show them this if needs be (but only after they have a good length of time to come up with their own ideas) and they can then discuss why this observation suggests that the Earth is a sphere.



Q; What would the approaching ship look like if the Earth were flat?
It would look like a tiny toy which just gets bigger and bigger. The fact that the top is always visible first shows that it is coming up over the curve in the Earth's surface.

The ancients also observed that:

- the Moon and the Sun appear to be circular and understood that a sphere looks like a disc when seen from a distance.

So, they thought that the Earth too might be curved, and they made the link between a disc shape and a sphere.

3. Day and night

The explanation for day and night involves the understanding that the Earth rotates (spins) on its own axis. This just means that the Earth spins around and the axis is at the centre of that spin. So, the UK faces the Sun in the day and hence is in the light; it faces away from the Sun at night and so is in the dark.

Teaching and learning considerations

The concept of the Earth rotating on its own axis is not at all easy. We are living on a sphere spinning around at high speed (about 700 mph in the UK)! Firstly, it does not look like we are moving at all and secondly, it looks just like the Sun moves around us, rather than vice-versa! In the Teaching Approaches section, big questions are used as a way of helping pupils think carefully about such things. The reason we do not have any sense of the motion is linked to relativity –absolutely everything moves with us. We do not have an idea we are moving unless we can see something that isn't or is moving at a different rate. This is why, when we are sitting on a train at a station and the train next to us seems to move, we can't tell if it is our train moving or the neighbouring train. In order to know, we have to look at the platform and if that it still, we are certainly not moving.

It is also important to link to the light section of the National Curriculum: the pupils need to understand need to understand that light travels from a source and that the Sun is a source of light.

Teaching approaches

The very best way for children to understand this is to act it out.

Make a simple tabard by laminating two A4 pictures of the Earth, use a hole punch to make 2 holes at the top of each picture, so string can be threaded through, and they can hang over a child's neck – one on the front and one on the back. Make two more tabards: one of the Sun and the other of the Moon.

Ask a pupil to stand in front of the class, wearing the Earth tabard. Tell them that they are the Earth and their nose is the U.K. Shine a torch at them (not too bright a torch!) and then ask them to spin around very slowly. Tell them that the torch represents the light from the Sun. When they are facing away from the torch, tell them to stop and ask the class what time of day it is. The nose of the person 'being' the Earth will not be in the light of the torch so it is dark and night time in the UK. Ask them to spin again until they are directly facing the torch and ask what time of day it is now - midday. Repeat at various points in the spin so they get a feel for evening, as they are about to go out of the light and morning, as they are about to come into the light.

It really helps the children to experience this for themselves. They can pair up with torches and take turns in being the Sun (holding the torch) and being the Earth (spinning).

Children know that day and night last 24 hours so, by acting this out, they will know at a deep level that the Earth spins on its own axis once every 24 hours.

Teacher tip: You can also model this motion for the class with a globe and a torch but don't let them miss out on acting it out for themselves.

The Earth spins on its own axis as we have discussed but it also goes around (orbits) the Sun.

More acting is needed here: using the tabards again, the Sun stands at the centre and the Earth spins and at the same time travels around the Sun.

The Earth goes around (orbits) the Sun once a year.

Now ask the child 'being' the Earth how they feel. They will be pretty dizzy! This leads on to the next big question:

Big Question: We have said the Earth is spinning and also going around the Sun, so why don't we sense the motion?

When we look around us, it does not look at all as though we are moving.

A common answer is that we are not very fast but this is not the case at all –the Earth spins around so we are moving at about 700 mph in the UK and, as well as this, it is also orbiting the Sun at a speed of about 66,000 mph!

A Year 5 child quickly came up with this answer:

'Because everything is moving with us, the trees, houses and everything'

Which is absolutely right – everything is relative! We do not have an idea we are moving unless we can see something that isn't or is moving at a different rate. This is why, when we

are sitting on a train at a station and the train next to us seems to move, we can't tell if it is our train moving or the neighbouring train. In order to know, we have to look at the platform and if that it still, we are certainly not moving.

4. The Moon

The Moon is a sphere and it orbits the Earth. It is quite safe to look at the Moon, even through a telescope, because the light that comes from it is not very intense. The Moon reflects the light of the Sun – it does not make its own heat and light. The Moon goes through phases so it seems to be different shapes at different times. A full cycle takes a month or 'moonth'. Hence from one full Moon to the next is one month.
The Moon always keeps the same side facing the Earth – the other side is the 'dark side' of the Moon. We never see the dark side from Earth and the only people who have seen it are the astronauts who have orbited the Moon.
It is an amazing fact that the Moon and Sun appear the same size in the sky. The Sun is much, much bigger than the Moon but is also much, much further away. In fact, the diameter of the Sun is 400 times the diameter of the Moon but it is also 400 times further away! This is a phenomenal co-incidence which means that the disc of the Sun, as we see it from the Earth, is almost identical in size to the disc of the Moon in the sky.
The Moon can therefore just cover the Sun and obscure it completely during a total eclipse.

Teaching and learning considerations
Again, this topic links to that of light and the fact that we need light to see things and that light is reflected from surfaces. The fact that the Moon is not a source of light is important and the pupils need to understand that it reflects the light from the Sun.

The reason for the shape of the Moon changing periodically, ie why it goes through its different phases is tricky and widely misunderstood, even by adults. Suffice to say that this is not caused by the Moon being in the shadow of the Earth. It is all about how much of the Moon we can see from Earth at any point in time and where it is in relation to the Sun and the Earth. It really is best *not* to try to explain this to primary children.

Teaching approaches
It is important for the pupils to observe the different phases of the Moon and the fact that it too seems to move across the sky in the course of a night.
Observations can be made of the Moon's appearance and how this changes over time and also when it can be seen in the sky. This really can only be done as a home project, but it can be tricky for children who go to bed early!
It is very good to ask the children what they think.
Question: What does the Moon look like?
Give them a night time scene and ask them to draw the Moon in the sky.

N.B. Many children's story books have the Moon drawn as a crescent and this is likely to be the most common response.

Question: When do we see the Moon in the sky?

Tell the pupils that scientists do observations and they are going to be 'Moon spotters' – when they see the Moon, they draw its shape and note the time.

Question: We know it is not safe to look at the Sun in the sky but it is quite safe to look at the Moon. Why is it safe to look at the Moon?

The Moon is nowhere near as bright as the Sun and this is because it is not itself a source of light. It reflects the light from the Sun.

A disco ball seems to shine but it is only reflecting the light falling on it – it is not a source of light.

Now the pupils can act out a slightly expanded model of the solar system with the Earth, Sun and Moon tabards:

Using the tabards again, the Sun stands at the centre and the Earth spins and at the same time travels around the Sun. Now add in the Moon which orbits the Earth whilst it orbits the Sun.

The Moon has the hardest job!

The Moon orbits the Earth once a 'moonth' – month.

An interesting fact: the Moon always keeps the same side facing the Earth – the other side is never seen from the Earth, and the only people who have seen it are the astronauts who have orbited the Moon.

So the child 'being' the Moon keeps his/her face looking at the Earth as they go around it.

Scale

The scale of our model of the Earth, Sun and Moon being acted out by the children is obviously nowhere near reality. The best way of getting a feel for the scale is the following demonstration:

Have two small beads hanging by threads from a rod. One bead represents the Earth and the other the Moon. The beads need to be about 10 cm apart so that the scale is roughly correct.

Tell the pupils that we have reduced the Moon and Earth by the same amount and then this is roughly how far apart they would be.

Hold the model up.

Question: Is the Sun larger or smaller than the Moon?

They tend to know the Sun is bigger. Have a bag with a variety of sized balls in it and bring them out one by one to see which one would be about the right size for the Sun:

- Golf ball
- Tennis ball
- Football
- Large beach ball

A really large beach ball is about right.

Question: How far away does the beach ball need to be for this scale model?
It can be thrown to the middle of the class, back of the class etc. but this would not be far enough - it needs to be 40m away! It is important to go outside and actually do this.
It is also interesting to ask the children what is between the Earth and the Sun. Admittedly, there are two other planets but these are also relatively tiny and are in constant orbit around the Sun. Children tend to have quite a crowded picture of space and think that there are other stars between us and the Sun. Mostly it is just empty space, no air – nothing at all.

Amazing fact: the diameter of the Sun is 400 times the diameter of the Moon but it is also 400 times further away! This is a phenomenal co-incidence which means that the disc of the Sun, as we see it from the Earth, is almost identical in size to the disc of the Moon in the sky. The Moon can therefore just cover the Sun and obscure it completely during a total eclipse.

5. Other planets

Our Earth is just one of the planets that orbit the Sun. Together, they make up the Solar System with the Sun at the centre.

Teaching and learning considerations
Children tend to have a very crowded view of space and this is not helped by the various diagrams of the Solar System that can be found on the internet. In order to see all the planets in one diagram, it has to be grossly out of scale.

Teaching approaches
Children love to learn about the other planets. The Sun and the planets that orbit around it form the Solar System.
Take them out onto the playground and let them be a planetarium and act out the orbits of the different planets around the Sun. Remind them that this is certainly not to scale.
The pupils can research amazing facts about the planets in our Solar System. Here are a few examples:

- What would happen to a saucepan of water placed on the surface of the planet, Mercury? - The saucepan would melt!

- Planets other than the Earth have moons: Jupiter has 16 moons and Saturn has at least 18!
- More than 1000 Earths could fit inside the giant planet, Jupiter.
- Saturn is also much larger than the Earth but its day is shorter than an Earth's day because it spins round on its own axis once in less than 11 hours. (Hence its day lasts just less than 11 hours).
- A year on Saturn lasts 29.5 times longer than our year because it takes 29.5 times longer to complete its orbit of the Sun.

They can then present their findings in any number of creative ways. One way is to divide the class into groups and give each group one planet to research. They could then present their findings as though they are a foreign correspondent reporting from that planet, telling us what it is like. They could report on the colour of the sky, the number of moons, how long the day lasts etc etc. Their reports could be shared in a school assembly; filmed and put on the school website or written up for a class/school newspaper.

6. The Milky Way and beyond…

A galaxy is a huge collection of stars. Our Sun is just one star among a hundred thousand million stars that make up the galaxy known as the Milky Way. The Milky Way is a spiral galaxy and the Sun is a star in one of the spiral arms towards the edge of the galaxy.
The universe is made up of about a hundred thousand million galaxies - each of which contain about a hundred thousand million stars……!

Teaching and learning issues

This beyond the remit of the primary National Curriculum but it is something that just fascinates many children and can be a source of inspiration for them. Thus it is important for the school library to have a good selection of astronomy books.

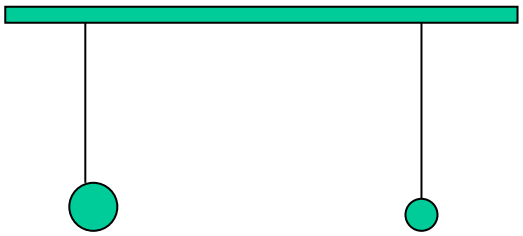
Teaching approaches

It is fun to write the school address on a universal scale – ask the pupils to try continuing that address:

……..Primary School,
Street
Town,
England,
U.K.
Europe,
Earth
……
……

The missing bits in the address are:
Earth
Solar System
Milky Way Galaxy
The Universe

Finally, revisit the beads on threads model used in the previous section about the Moon.



As previously, one bead represents the Earth and the other the Moon. The beads need to be about 10 cm apart so that the scale is roughly correct. On this scale, the Sun is represented by a large beach ball 40 m away.
Hold this model up, with a large beach ball, explaining that it needs to be 40 m away and then ask the children:
Big Question: what is between the Earth and the Sun?
There are two other planets, Mercury and Venus, but these are also relatively tiny and are in constant orbit around the Sun. Children tend to have quite a crowded picture of space and often think that there are a vast number of things, including other stars, between us and the Sun. In reality, there is just about nothing – no air, nothing.
Then ask them to think about all the myriad of stars seen in the night sky.
Big Question: Where, on this scale, would our nearest neighbouring star be found?
Ask for suggestions. They may say in a town 1 km away, or even 30 km away…
Incredibly, on this same scale with the Sun 40 m away from the Earth, the nearest star would be 4000 km away!! So if the bead model is held up in a school in the UK, the model Sun is 40 away on the same scale, and the *nearest* neighbouring star would need to be in Canada!!!!
Such is the awesome scale of our universe.

Amazing facts:
Light travels faster than anything else we know – at 300,000 km per second (186,000 miles per second). If light could travel in a circle it would travel around the Earth 7.75 times per second! Of course, it can't do that but it gives us a feel for this awesome speed. When we see a star, the light has travelled from it at that speed to our eyes through the emptiness of space. It takes the light from the nearest star just over 4 years to reach us. Light from other stars takes hundreds of years, thousands of years, millions of years, so we see history when

we look at the night sky. We see the stars as they looked when the light left them all those years ago.
The Hubble telescope is in orbit outside the Earth's atmosphere and it is well worth looking on the internet for some of the amazing photographs taken from it. It 'sees' well beyond the scope of our naked eyes or that of Earth bound telescopes. There are a number of pictures of deep space and the galaxies in them are so far way that the light left them when the dinosaurs lived on Earth and has been travelling through space at 300,000km per second ever since and only now has reached the telescope!

Health & Safety:

Teachers need to risk assess practical activities for their children following the advice of their health and safety advisor.

Teachers always need to defer to their health and safety advisor for the most up-to-date source of health and safety guidance. This training cannot be relied upon as a source of health & safety guidance.