Physics > Big idea PES: Earth in space> Topic PES1: Solar System and beyond

Key concept (age 11-14)
PES1.3: Night sky, stars and galaxies

What's the big idea?

A big idea in physics is of Earth in space. This is important because we live on the Earth and it is the only planet that we know to have abundant and complex life. Understanding how the Earth and space systems interact, how they affect us, and how we affect them is vital for our survival. Exploring our origins and our place in the universe feeds the intrinsic curiosity of humans and develops a sense of wonder.

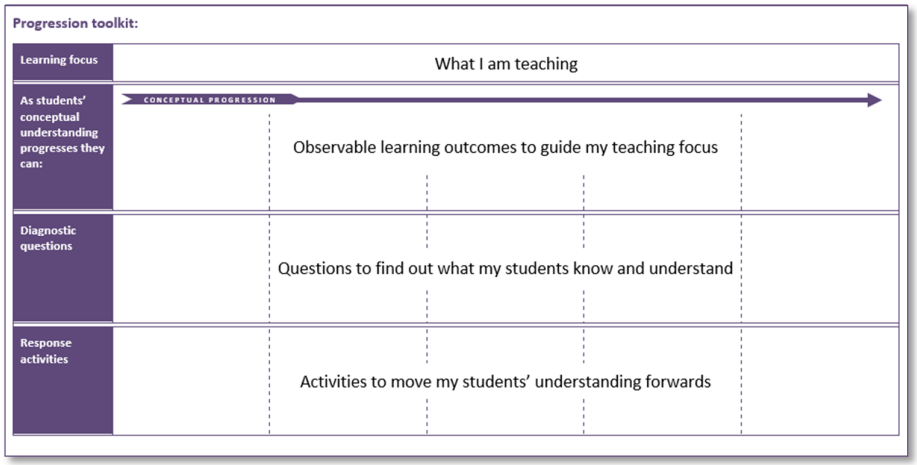
How does this key concept develop understanding of the big idea?

This key concept helps to develop the big idea by building on the understanding that the Sun is one of many stars visible from a spinning Earth, and by interpreting observations of the night sky to establish a general understanding of the large structure of space.

The conceptual progression starts by checking understanding that the Sun is a star. It then supports the interpretation of observations of the Sun and other stars in order to enable understanding of the nature and scale of galaxies and the universe.

Using the progression toolkit to support student learning

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.



Progression toolkit: Night sky, stars and galaxies

Learning focus	The Sun is one of billions of stars in our galaxy and our galaxy is one of many billions of galaxies in the universe.				
As students' conceptual understanding progresses they can:	CONCEPTUAL PROGRESSION →				
	Identify the Sun as a star **P**	Explain why Sun looks bigger and brighter than other stars	Describe how the stars (and Moon) appear to move in the sky	Explain why only a few thousand stars can be seen at night with the naked eye	Describe how stars group together, billions at a time, to form galaxies and how there are billions of galaxies in the Universe
Diagnostic questions	The Sun	A distant Sun	Moon and stars	Seeing stars	Galaxy of universe?
Response activities	Stars and planets			Counting stars	

Key:

P Prior understanding from earlier stages of learning

What's the science story?

The position of the Moon and the stars in the sky changes during the night. The stars all move together, so that their patterns remain the same. Groups of stars are called constellations (for example, the Plough and Orion).

Day and night, and the apparent motions of Sun, Moon and stars are due to the rotation of the Earth on its axis. A full rotation takes 24 hours.

The Sun is a sphere. It is very hot. It (emits radiation that) illuminates and warms the Earth. Solar radiation illuminates the half of the Earth's surface that is facing towards the Sun. The Sun is many times bigger than the Earth and looks small because it is far away.

The Sun is a star. Like the Sun, other stars are very hot and emit radiation. They appear very much smaller and fainter than the Sun because they are at vastly greater distances. A convenient unit for measuring such distances is the light-year, ly. 1 ly = distance light travels through space in 1 year ($\approx 10^{16}$ m).

(The nearest stars to the Sun are a few light years away. For comparison, light from the Sun's surface takes only a few minutes to reach Earth, and a few hours to reach Neptune. Stars further than a few hundred light years away are too faint to see with the naked eye)

In space stars are found in groups called galaxies. Each galaxy contains hundreds of billions of stars. (Evidence for galaxies was discovered in 1929.)

What does the research say?

It can be tempting to keep work on the Solar System simple and descriptive when in fact it is conceptually demanding (Osborne, 2011). The scientific explanations for simple observations such as the Sun moving across the sky each day are not obvious and sometimes counter intuitive. The Sun's 'movement' across the sky happens not because the Sun is moving, which is the most obvious explanation, but because the Earth is spinning on its axis. In the sky the Sun appears to be smaller than the Earth but in fact is much bigger and very far away. The Moon looks to be the same size as the Sun, but is much, much smaller and also much closer. For similar reasons stars appear to be tiny and therefore very different to the Sun.

In a study (n=25 for each age range) about half of students aged 11-12 thought that night and day were caused by the movement of the Sun with just 20% giving the correct explanation; by age 13 or 14 about half could explain how day and night are caused by the Earth spinning on its axis (Baxter, 1989). It may be that by keeping work on the Solar System simple and descriptive students are allowed to maintain their misunderstandings. One of the key findings of Lelliott and Rollnick's (2009) review of astronomy education research (1974-2008) was the need for teachers to use physical models both to scaffold learning and to challenge misunderstanding.

In a study only about half of 10- and 11-year-olds (n=42) realised that the Sun is a star and three-quarters described the Sun as a huge ball of fire (Sharp, 1996). Around three-quarters also thought of stars as round or 'star-shaped' (with five points), but they were not aware of the stars position in space or their movement. The misunderstanding, that the Sun is different to the stars, is persistent and just 55% of adults identify the Sun as a star (Lightman, Miller and Leadbetter, 1989).

When asked to describe their observations of the night sky, students could more readily describe the daily motion of the Moon than the stars (Plummer and Krajcik, 2010). In a sample of 13- to 14-year-old students (n=60) 60% knew that the Moon rose and set in the sky compared to 15% who knew that stars do the same. Only 40% of these students knew that stars appear to move (at all) during the night. These findings support Plummer and Krajcik's (2010) recommendation that a learning progression on celestial motion describes the apparent motions first of the Sun, then of the Moon and finally of the stars.

A study found that US college students (aged 17-19, n=199) commonly provide incomplete definitions of common objects: Solar System, galaxy and the Universe itself, often conflating the terms (Bailey et al., 2012).

Relatively little research has been completed on students' understanding of distances in space and the research that has been done indicates that this is one of the weakest areas of knowledge in astronomy for 11-16-year-olds (Lelliott and Rollnick, 2009).

The progression toolkit for night sky, stars and galaxies reminds students that the Sun is a star. By considering why the Sun is bigger and brighter than other stars students are given the opportunity to consider how far away other stars must be. The apparent motion of the stars through the night sky is explained by the spinning Earth, which gives students the opportunity to develop a scientific understanding of the Earth (and Solar System) surrounded by a field of distant stars. This understanding is explored further by observing how stars that are further away appear dimmer and by considering the existence of many more stars too far away to see. Students describe the larger structure of the universe, which has been observed with modern telescopes, to help consolidate their understanding.

Guidance notes

Much of what students understand about the large scale structure of space is from television and other media. Science fiction films can distort the true picture (for example they rarely show the vast tracts of 'empty' space between galaxies). Carefully selected videos and animations can however be very useful in giving students a visual representation of what space is really like. A few suggestions have been made in the teachers' notes in some of the questions and activities in this key concept. Three excellent sources are the BBC: http://www.bbc.co.uk/science/space/ , the European Space Agency: https://www.esa.int/ESA , and NASA: https://www.nasa.gov/ .

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