Video question script: Clay balls and Earth's structure

Question/Activity	Likely response	Rationale
In teaching about the Earth we use practical activities to explore Earth processes. This example explores how we can model evidence for the Earth's core, through the Earthlearningidea 'From clay balls to the structure of the Earth'		Preparation for bridging from the model to real Earth properties
Prepare several sets of clay or Plasticine™ balls of two colours. The balls of one colour are made of clay/ Plasticine™ only, balls of the other colour have a steel ball bearing in the centre		
Give each group of pupils a pair of balls Say that the balls are not to be damaged or destroyed Ask: Can you detect any differences between them, apart from the colour?	• One ball seems heavier • One ball seems more dense	Concrete preparation: explaining about the balls Construction: seeking a pattern (based on density)
Ask: How could you find out if you are right?	• Weigh the balls – one would be heavier • Measure their densities – one would be denser • Spin or roll the balls – one would spin or roll for longer, it has greater inertia and so is heavier	Bridging: application from their previous experience
If you had time, you could carry out any or all of these tests	• One would be found to be heavier • One would be found to be more dense • The spin/roll test does not work because the clay will not allow free spinning/rolling	
There are five hypotheses which could account for the fact that one ball is heavier than the other. What are they? Give time for group discussion	• There is something heavy inside one ball • There is something light (e.g. air) inside one ball • One ball is made of denser clay than the other Most groups do not work out these last two hypotheses: • One ball gets steadily heavier towards the middle • One ball gets steadily lighter towards the middle	Cognitive conflict: considering different ideas that could explain the pattern
Ask: Without destroying the ball, how could you find out which of these ideas is correct? You could use any equipment in this room, in this town or in this region. Give time for group discussion	• Stick something like a needle into each ball (although some may say this is destroying it) • Take a small amount of the surface of each ball to measure its density (destroying the ball?) • Test with a magnet (or magnetic sensor) • Test its inertia (maybe mentioned above) • Test it with ultrasound • Test it with electromagnetic resonance (EMR machine in hospitals) • X-ray it • Test it with ionising radiation (alpha, beta, gamma)	Cognitive conflict: considering different testing methods
Comment on what each of these methods would find	• The needle would find the ball bearing in the centre of one of the balls • The density test would find the same densities for the surface Plasticine™ • A strong magnet would attract the ball-bearing ball and not the other • Inertia tests don't work (see note above) • All the other methods would detect something in the centre of the ball-bearing ball, and not in the other	

Ask: Which of these could you use on the Earth in an attempt to find out what is in the middle? Give time for group discussion	• Needle test - like drilling a borehole on Earth. This would fail because boreholes cannot drill deep enough. The deepest borehole on Earth is the Kola Superdeep Borehole in Russia at more than 12km, however the depth to the core (simulated by the ball bearing) is 2890 or nearly 3000km (ref. a mosquito bite on an elephant) • Density test – the density of the crust is 2.7-2.9 gcm^3 but the density of the whole Earth is 5.5gcm^3, so there must be something heavier in the middle (the core) • Magnet test – both a compass and a dip needle show there is something causing the Earth to be magnetic – thought to be the core • Inertia tests – measurement of the Earth's inertia shows a heavy core • Ultrasound test – cannot penetrate the Earth (can only detect a foetus in a mother's womb); sonar (sound) cannot penetrate the Earth either, but is very useful for mapping the seabed; infra-sound (low frequency shock waves or seismic waves) do penetrate the Earth, and give the best evidence for the core • X-ray test – X-rays cannot penetrate the Earth, they are stopped by bones in our bodies • Ionising radiation test – α (alpha) radiation cannot penetrate my hand; β (beta) radiation) can just penetrate my hand; γ (gamma) radiation can penetrate several metres of concrete – but nothing like the whole Earth	Cognitive conflict: considering which of these methods could be used on the Earth Bridging: from the clay balls to the whole Earth
Summarise the methods giving evidence for the Earth's core	• Density • Magnetism • Inertia • Infra-sound (seismic)	
Ask: We could have just taught about the Earth's core by asking pupils to draw and label a diagram (so learning about the science of the Earth), but have we just been 'doing' science rather than learning about it?	When scientists 'do' science, they: • ask questions • come up with ideas to answer these questions (develop hypotheses) • think of ways of testing these ideas (observations or experiments) • think what these are likely to tell us …. just as we have been doing here So we have been 'doing' science rather than just learning about it	Metacognition: thinking about thinking and discussing this

Note: This idea was published as, King, C. (2002) The secrets of Plasticine balls and the structure of the Earth: investigation through discussion. *Physics Education,* 37 (6), 485 – 491 – from which this script has been developed.