Physics > Big idea PEM: Electricity and magnetism > Topic PEM1: Simple electric circuits

Key concept (age 11-14)

PEM1.2: Electric current

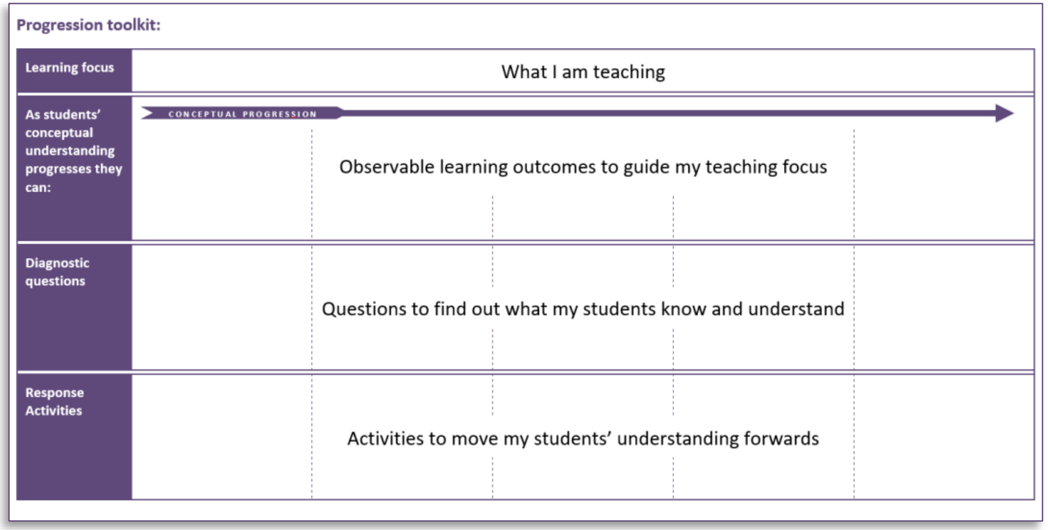
What's the big idea?

A big idea in physics is electricity and magnetism. The familiar everyday world we live in is largely a consequence of the properties and behaviour of electric charge. Matter is held together by electrostatic forces, and these influence chemical changes. Electricity and magnetism initially seem distinct phenomena but are later found to be closely interrelated. Understanding electricity and magnetism helps us to develop our technology and find applications that can transform our everyday lives.

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

This key concept develops the big idea by focusing on the understanding that current goes round a circuit, makes things happen and is not used up in the process. This can be a difficult concept for students to understand, but is a necessary step in a scientific understanding of electricity.

The conceptual progression starts by checking understanding of current as a flow of 'electricity'. It then supports the development of thinking about what is flowing in order to enable understanding of how adding different components affects the current, in all places around a series circuit.



How can you use 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.

Developed by the University of York Science Education Group and the Salters' Institute.
This key concept may have been edited. Download the original from **www.BestEvidenceScienceTeaching.org**

Progression toolkit: Electric current

Learning focus	Electric current is the flow of electric charge around a circuit that stops or starts flowing everywhere in the circuit at the same time. In a series circuit the current is the same in all places.				
As students' conceptual understanding progresses they can:	CONCEPTUAL PROGRESSION → Define current as a flow (of 'electricity') around a complete circuit that is measured with an ammeter.	Recognise that current is the same at each point around a simple series circuit because it is not 'used up' when it goes through a component.	Describe the flow of current from one end of the battery, through a circuit and back to the other end of the battery.	Explain why every part of a circuit starts working immediately that the circuit is turned on, using the idea that electric charges are already distributed throughout the whole circuit.	Explain how different components added anywhere in a circuit affect the current everywhere in the circuit, with batteries pushing harder and resistive components opposing more.
Diagnostic questions	Ammeter	Current in a circuit	Describing current	Big circuit Current and charge	Adding a motor
Response activities		Simple series circuit	Adding bulbs	String loop model (current) Flow	Adding a resistor

What's the science story?

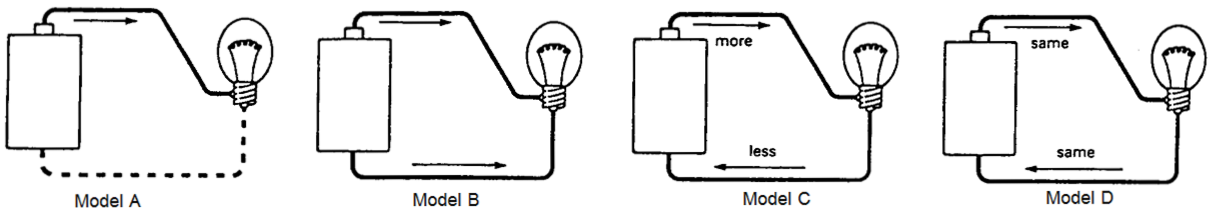
An electric current is a movement of charged particles. The wires and other devices in a circuit are full of charges (electrons) that are free to move. These charges all move together (like a continuous belt, or chain). Because they are negatively charged, electrons move away from the negative terminal of the battery and towards the positive terminal.

The size of the electric current at a particular point in a circuit is a measure of the amount of electric charge passing through that point every second. An ammeter is a device that measures the size of the electric current going through it. The unit of electric current is the ampere (or amp, A).

Adding a component *anywhere* in a series circuit will affect the current *everywhere* in the circuit.

What does the research say?

Whilst children may appreciate that batteries have two terminals, and that a closed loop of wire is needed for the lamp to light, their models of what is happening may be quite different from the accepted scientific model. Research suggests that many children hold one of the alternative models A-C in the figure below, rather than the accepted scientific model D (Driver *et al*, 1994):



Model A: A consumption model in which 'electricity' emerges from one end of the battery and is all consumed by the lamp which lights up. Sometimes described as the 'unipolar model'.

Model B: A reaction model in which two types of 'electricity' emerge from the battery – one from each end – and react in the lamp to make it glow. The 'clashing current' model.

Model C: An attenuation model in which some of the 'electricity' which emerges from one end of the battery is consumed in the lamp which lights up, while the rest returns to the other end of the battery. The 'current consumed' model.

Model D: A circulation model in which all of the 'electricity' emerging from one end of the battery squeezes through the thin wire in the lamp filament causing it to glow, and then returns to the other end of the battery.

Many researchers (e.g. Driver *et al*, 1994; Gott, 1984; Shipstone, 1985) have found that students' explanations at an early stage are likely to use the words current, voltage, electricity and energy to mean the same thing. To advance their understanding of electric circuits it is necessary for them to distinguish between: the current flowing through the circuit (that is conserved); the energy that is stored in the battery and then transferred elsewhere (that is conserved); and the voltage.

The string loop to model current has been used in this key concept mainly because it is a mechanical analogy. Research suggests (Dupin and Joshua, 1984; Hartel, 1984) that mechanical models (rope loops, bike chains, pushing trains on a track etc.) are more effective at helping students recognise that all points in a circuit influence all others. Millar *et al* (2006) also suggests that using the same model repeatedly for electric circuits is more effective than trying to reinforce the learning with several different ones.

The progression toolkit for electric current supports a constructive approach to teaching about current, which is very similar to that outlined by Strawson (2011). It reminds students of the concept that electricity is 'something' flowing around a circuit, and introduces them to using an ammeter to measure of how much current flows. Students can practise using an ammeter to test and confirm the idea that the flowing current is not used up, and apply their understanding of this to new situations. Once they have understood that current is conserved around a circuit, a mechanical model can be used to explain the observations in a 'big circuit': that every part of a circuit affects every other part *instantly*. Once again, giving students opportunities to apply their thinking in novel situations helps them to develop and reinforce the scientific model of electric current.

Guidance notes

We have used ammeters to compare currents around circuits and *not* the brightness of bulbs. It is intuitive for students to link the brightness of a bulb with the size of the current through it, but this is only true when the bulbs are identical to each other. Two different bulbs will vary in brightness when the same current passes through each. Ammeters may therefore be better for probing students' understanding of the behaviour of current.

References

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