

## Key concept (age 11-14)

### PEM1.1: Making circuits

#### 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.

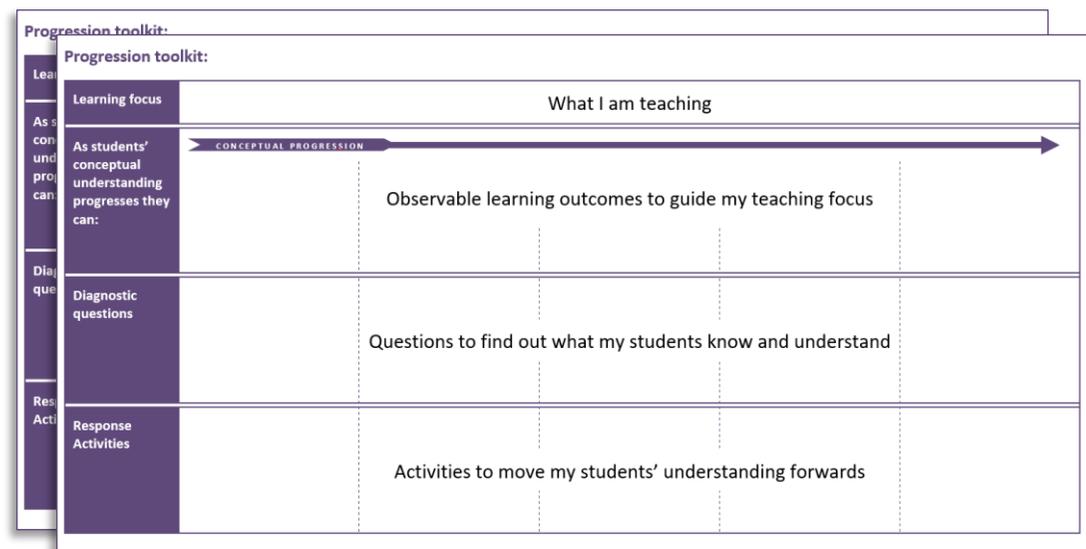
#### How does this key concept develop understanding of the big idea?

This key concept develops the big idea by building on existing understanding of circuits in order to provide the foundations for understanding of unfamiliar concepts such as current and voltage (PEM 1.2 and PEM 1.3)

The conceptual progression starts by checking understanding of complete circuits. It supports the development of skills in building circuits from circuit diagrams and testing for breaks in circuits, in order to enable students to fault find in more complex circuits.

#### 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: Making circuits

Learning focus	Electric circuits are represented using circuit symbols and specific circuit diagram conventions				
As students' conceptual understanding progresses they can:					
	Build simple circuits from pictures or demonstrations.  <div style="text-align: right;"><b>P</b></div>	Identify components from their circuit symbols, and draw the circuit symbol for common components.  <div style="text-align: right;"><b>P</b></div>	Identify circuit diagrams that represent a series circuit by tracing round the circuit.  <div style="text-align: right;"><b>P</b></div>	Interpret circuit diagrams to build series circuits.  <div style="text-align: right;"><b>P</b></div>	Use circuit symbols and circuit diagram conventions to draw clear and precise circuit diagrams of electrical circuits.  <div style="text-align: right;"><b>P</b></div>
Diagnostic questions	Circuit from a picture	Circuit symbols	Circuit diagrams (1)	Circuit from a diagram	Circuit diagrams (2)
Response activities	Building circuits (1)			Building circuits (2)	Drawing circuits

Key:

**P** Prior understanding from earlier stages of learning

Progression toolkit: Making circuits

Learning focus	An electric circuit is a closed conducting loop containing a battery.				
As students' conceptual understanding progresses they can:					
	Predict if a circuit will work, by tracing the circuit to find out if it is complete.  <b>P</b>	Describe how a simple circuit can be used to identify conductors and insulators.  <b>P</b>	Describe how a simple circuit can be used to test for faulty components, and trace the circuit through components to identify breaks in the conducting loop.	Describe how a switch in a circuit affects the flow of electricity everywhere instantly.	Explain how to fault find, and fix, a more complicated series circuit without taking it apart.
Diagnostic questions	Will it work?		Bulb in a circuit	Switches in the circuit	Circuit repair
Response activities			Light a bulb	Broken circuit	Fixing circuits
			Testing components		

Key:

**P** Prior understanding from earlier stages of learning

### What's the science story?

A simple electric circuit consists of a single device connected by wires to the two terminals of a battery (or power supply), perhaps with a switch somewhere in the loop. When it is switched on, there is an electric current everywhere in the circuit instantly.

Standard symbols are widely used to represent electric circuits. These show the connections in the circuit, but not its physical shape or appearance. Circuits are normally shown as rectangular, with right angled corners and straight connecting wires.

### What does the research say?

Research shows that the ideas of students aged 11 about how circuits work will be influenced by their day-to-day observations and use of language. For example:

- most electrical appliances at home are connected to the mains by a single lead
- reference to electrical devices 'using up' electricity
- descriptions of batteries 'going flat'.

A combination of the first two bullet points reinforces an image of electricity as a 'fuel' which is used up in an appliance. The third bullet point implies something is getting used up when circuits are switched on. (Driver *et al*, 1994)

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.

In an extensive study (Gott, 1984) it was found that even setting up circuits, to test ideas, can be a problem for many students. Most students are competent in recognising circuit symbols and using circuit diagrams to answer questions, but difficulties often arise whenever students translate a circuit diagram into a real circuit.

Appreciating what is happening in a simple electric circuit is not helped by the use of MES (mini Edison screw) bulbs in circuits and in diagrams. The construction of the MES bulb is not obvious. The path of the current flowing in through the base connection of the bulb, through the filament wire and then out through the metal screw fitting is often not clearly understood. If MES bulbs are used it may be helpful to make this explicit by showing students how they are constructed and how they connect in the bulb holder and to the circuit (Gott, 1984; Shipstone, 1985).

The first progression toolkit for making circuits introduces the students to your equipment. Some students may need to start with one-to-one pictorial representations before progressing to more abstract representations of circuits and components as their understanding develops. Other students may be able to interpret and draw their own circuit diagrams straight away. Giving students a series of challenges will allow students plenty of opportunity to handle electric circuits, and should help them to progress more quickly later on (Strawson, 2011).

The second progression toolkit for making circuits reminds students of the concept of a complete circuit and that ‘electricity’ flows through conductors, but not insulators. When they have understood the idea that electricity flows through conductors, they can use this idea to test for faulty components, that it does not flow through, and describe how switches work. Fault testing without taking a circuit apart forces students to apply their understanding of conduction and complete circuits to new and more complex situations. As Strawson (2011) notes, giving students opportunity to practise in setting up and checking circuits is likely to avoid frustrations and allow students to make faster progress.

### Guidance notes

Many students move into secondary education, and change schools, at age 11 and, if this is the case, it is likely that the electric circuit equipment that you will be using is unfamiliar to them. This can strongly influence the ease with which they will recall their earlier learning and, before progressing, it is most probably necessary to spend some time building circuits and reminding them of what they have already learnt.

Many students who have difficulty building circuits, approach the task in a fairly random way. Encouraging them to start at one point on the circuit diagram and following it round in a loop, will help them to systematically construct the circuit in the correct logical sequence.

When a switch is described as closed, it is turned on and electric current flows everywhere at once. When a switch is described as open, it is off and current stops everywhere at once. The words closed and open refer to the circuit being closed or open. It is useful to use this language with students as it often appears in exam questions, but making their meaning explicit may help students’ comprehension.

NB ‘Battery’ has been used throughout for clarity. Strictly speaking an ‘electric cell’ is a single device producing or storing electricity and a battery is a combination of one or more electric cells connected together to provide the voltage required to operate some device or other.

### References

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). ‘Electricity’, in *Making sense of secondary science* (pp. 117-122). London: Routledge.

Gott R. (1984). *Electricity at age 15: a report on the performance of pupils at age 15 on questions in electricity*. London: Dept. of Education and Science, Welsh Office, Dept. of Education for Northern Ireland.

Shipstone, D.M. (1985). ‘Electricity in simple circuits’, in Driver, R. (Ed.), *Children’s ideas in science* (pp. 33-40). Milton Keynes: Open University Press.

Strawson, R. (2011). ‘Electricity and magnetism’, in Sang, D. (Ed), *Teaching secondary physics* (pp. 151-202). London: Hodder Education.