Common Misconceptions

Electricity

Kate Redhead, PSTT Regional Mentor, tells us how she helps children understand the **Principles of Electricity.**

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What children need to know:

- *A simple circuit consists of a series of conductors.*
- *That some materials, such as metals, are conductors and others, such as plastic, are insulators.*
- *A circuit needs to be complete to work.*
- *The number and voltage of cells in a circuit, affect the brightness of the bulb or loudness of the buzzer.*
- *The reasons for differences in how components behave in a circuit.*
- *The different symbols that represent a simple circuit.*

Common misconceptions – often children may think that:

- *Different coloured wires affect how the circuit works.*
- *Wire is made of plastic.*
- *If a circuit is broken, energy goes off into the air.*
- *Electricity comes out of both sides of the battery and leads to both sides of the component.*
- *Current, voltage and electricity are all the same thing.*
- *Current gets less as it passes through components.*
- *Electricity is an object that can be seen.*

As teachers, if we're honest, there is always an area of the curriculum that we find 'challenging' to cover; the one we need to go over more thoroughly before we can facilitate it with full aplomb in the classroom. In science, for me, it has always been electricity.

WHY ELECTRICITY?

The abstract nature of energy being passed around a circuit seems to be the root of the cause; children can see the result (a buzzer sounding for example) but not what is making it happen; it is invisible. Research suggests that with abstract concepts like these, if we are not adequately able to encourage children to recognise what is happening, then they may leave the lesson having said all the right things and seemingly taken on board the learning, but actually still hold onto their own ideas about 'what is really happening' (Harlen and Qualter, 2006).

As with all science topics, the common use of words or phrases can also lead to misconceptions. We often refer to a single cell as a battery and speak of 'turning a light on' rather than making a bulb light up.

MY OWN REVISION!

The fear of passing on my own possible misconceptions to the children, drives me to go back to basics before teaching the topic. Key terms and definitions, appropriate for primary level, are my starting point (see Table 1).

Electricity	A form of energy.
Charge (electron)	An electric current flows when electric charges move through a wire. Just as in a flowing water system, the charge is analogous to the amount of water in the system.
Current	The movement or flow of electrical charges. This is measured in amps (A). The greater the charge that flows, the bigger the current. Just as in a flowing water system, the current is analogous to the flow of water.
Voltage	The voltage provides the force that pushes the current around the circuit. A voltmeter measures voltage in volts (V). The higher the voltage, the more current is passing through the component and if this is too high, a bulb could blow. Just as in a flowing water system, the voltage is analogous to water pressure.
Cell (electrical)	This generates the electrical energy (e.g. through chemical reactions that occur within the cell). When a cell is connected to a complete circuit, it provides a flow of electrical current to the components.
Battery	One or more than one cells joined together.
Components	The different parts of a circuit, for example: bulb, buzzer etc.

Table 1: Key terms and definitions

Whilst the curriculum may not dictate that children are clear on all of these formal terms when electricity is first introduced, I always use them in context as a way of slowly introducing science vocabulary that can be build on at key stage. However, I do exclude the use of the term 'electron' as this is not included in the curriculum until key stage 4.

WHERE TO START IN THE CLASSROOM

Give children a set of circuit equipment and usually, they can make a component work without much difficulty. However, I prefer to start with a 'wow' and for this I use an 'energy ball', 'energy stick' (Figure 1) or 'circuit maker breaker', which literally provides a hands-on approach to exploring circuits. Each contains an open circuit that produces light and/or sound when completed – the children should offer explanations as to how this works.

Figure 1: Energy stick

These devices are cheap to source, and work when the metal strips are touched on both sides and a connection is made across the surface of the skin (impurities in the sweat on our skin carry the current). In a class situation, they are an excellent tool to involve every child by forming a 'magic circle' (slowly increasing the number of children holding hands in a circle whilst keeping the connection on the metal strips). There are numerous possibilities for extending the learning in this: exploring whether different materials are electrical conductors and considering how switches work are just two examples.

EXPLORATION AND TAKING OWNERSHIP

Next steps for me are to give the children chance to explore; baskets of equipment on each table (including bulbs and cells that are separate from their holders) and a variety of prompts at the ready for those that need it (Can you make a bulb light? Can you change the direction of the motor? Does it matter which way around the cell is? Etc.). As the children explore and make their own discoveries, I prompt them for predictions and explanations (see Figure 2). The aim is for the children to take ownership and begin to pose their own questions to investigate.

Post-It notes of the children's discoveries placed on a learning wall are a useful tool for identifying misconceptions and if time permits, I encourage the children to investigate further; often they will then reassess their findings as their explorations progress. I also use this time to encourage children to recognise what is inside a wire, ensuring they know that the plastic is the coating and not the conductor.

ASSESSING FINDINGS AND USING MODELS TO ADDRESS MISCONCEPTIONS

Children are usually able to say what they think happens in a circuit and how they can change its results, but less clear on what is making it happen. Practical activities and models are excellent tools to address misconceptions, and if all children can be physically involved in a demonstration, they are much more likely to develop a thorough understanding. Whilst we all have our favourites, there is no perfect model, all having limitations and the children should be encouraged to identify these.

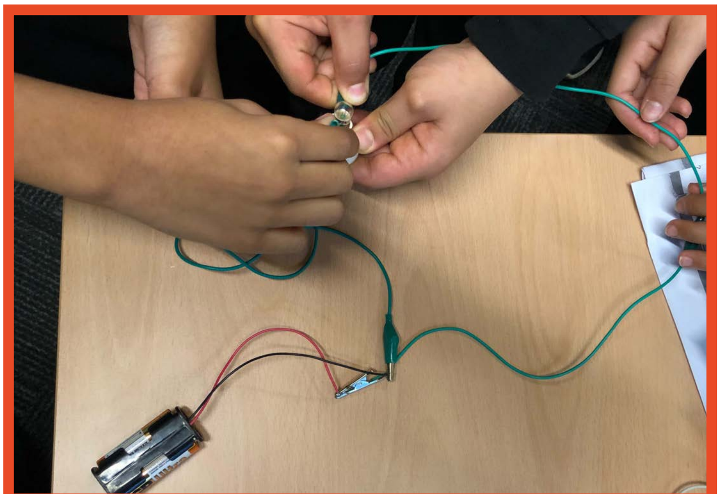

Figure 2: Children exploring with electrical equipment

The first model I share is controversial! Some might say, it deepens a child's misconception that there is only one charge travelling around the circuit and that the charge takes time to travel from the cell to the bulb. I would argue that it allows this misconception to be addressed head on.

I start with the **'whole-class circuit'** and have a 'two stages' approach:

1. 'Passing the squeeze' around the circle first introduces the movement of charge in the circuit. A child wears a 'cell' hat and another a 'bulb' hat (Figure 3). The cell calls, "Go!" as they start the squeeze and the bulb, "On!" as the squeeze reaches them. Children could decide how they can show the effects of adding extra components into the circuit.

I then encourage children to recognise that the bulb was calling, "On!" only when the squeeze reached them and pose the question, "Did the bulb go on and off in the circuits we made?" This is where the misconception is addressed, as children see the difference between the model (with a bulb lighting intermittently, whenever the squeeze passed through it) to the actual circuit they created (where the bulb was lit whenever the circuit was complete). By

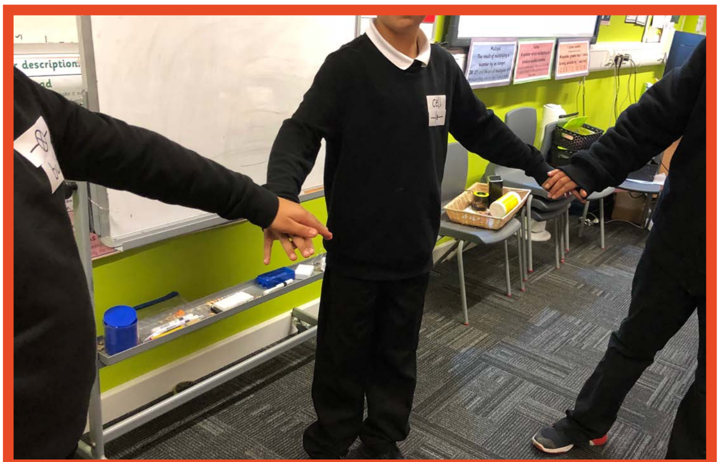

Figure 3: Children holding hands in a circle

demonstrating and underlining these differences, children see that there is not just one charge.

2. The 'Paper Game' helps the children understand that the charges are in the wires and all components. Each child in the circle is given a piece of scrunched up paper (or similar item) on which each child writes 'charge' and told they cannot not pass it to their neighbour until their other neighbour is ready to give them theirs. The cell and component hats are still used, but now have 'On' written on the reverse sides. Children determine when to turn them, depending on the movement in the circle.

In moving the model forward, I want children to recognise the following:

- *Electricity does not travel by a single charge to the component and then away again, but that there are many charges that all move simultaneously when the cell introduces the push force, and all stop when the circuit is broken.*
- *Current flows through components and is the same when it exits as when it enters (it is not 'used up').*

TAKING IT FURTHER: A REASON TO INVESTIGATE

I then give children a reason to investigate further and apply their understanding. Electricity lends itself brilliantly to construction-based projects and wherever possible I link this to their Design Technology topic. A prompt based on a problem, (e.g. "Adam is struggling to do his homework because his light isn't bright enough…") or a story ("The Lighthouse Keeper's Son" in 'Science Through Stories' by Jules Pottle and Chris Smith) are possible approaches. Children can then plan and carry out their own construction based on their new knowledge and go on to discover how changes to cell voltage and numbers of components affect how these behave.