Fun Size: Electricity Models — Teacher notes

Introduction

This is a document about using modelling activities. The intended audience is teachers. Modelling will be an important strand of the KS3 Science Strategy and Framework. The *Electricity* resource on this CD ROM is an interactive electricity analogy to use with pupils.

Lesson outcomes

- Electricity concepts

Where the activity fits in

Any electricity topics

Skills

Knowledge and understanding, recall, vocabulary.

Acknowledgements

This document draws heavily on information from *Pathways Through Science: Electricity: Teacher's Guide*.

Pathways Through Science was a Longmans / Nuffield publication in the early 1990s but is now out of print.

Developing ideas in electricity

Models of electricity
Students will find it helpful to have a model to help them think about 'electricity'. Without a model they can easily feel that electricity is abstract, inaccessible and just 'too difficult'. You should encourage students to develop their mental models of electricity.

Students inevitably start with some conception of the nature of electricity. They should continually examine their models, and to develop more refined versions, appropriate to their own level of understanding. The model must be "good enough" to explain the concept they are thinking about, but they can modify it later.

The problem for teachers is to decide which model (or models) is or are likely to be most helpful to them. Teachers will have their own preferred explanations they may wish to use; they will also have their own, more sophisticated version which they may regard as 'more correct'. It is important that a Science Department should discuss the models, reach a consensus and try to use the same models in all their teaching of electricity.

Presented here are several models of electricity, some at a higher level than others. These are outlined below, followed by some other ideas which teachers may find useful when students are looking for further ideas, or when they ask awkward questions.

A model is a good one if it allows students to solve problems at their own level. Any model is inevitably flawed, and will only be a partially true picture of reality. However, better a flawed idea which is understood than an over-elaborate idea which the student does not feel comfortable with.

Thinking about electricity
We talk loosely about 'electricity'. Sometimes we mean the flow of electric **current**, at other times we mean something to do with electrical **energy**. It is important to separate these out.
Electric current flows all the way round the circuit – 'the amps'.
Energy is carried round from, for example, the battery to a bulb – 'the volts'.

This gives two basic levels for models to expand on this distinction:

- (at lower levels) current is the flow of electric charge round a circuit. An ammeter shows how much flows each second. The basic amount of charge is a coulomb.

Voltage is the push which makes electric current flow. It is provided by power supplies and cells. It is measured (in volts) using a voltmeter. The greater the push, the more energy the current carries.

- (at higher levels) current is the flow of charged particles round a circuit. (The particles may be electrons or ions). The particles are given energy by power supplies and cells; they give up their energy to bulbs, motors and so on. Voltage is a measure of the energy carried by the charged particles. A 1.5 v cell gives each coulomb of charge 1.5 J of energy.

Peas in a tube
We can picture the charged particles in a wire as being like peas filling a tube. Push an extra pea in at one end and another (different) pea falls out at the other end.

This model is useful as it explains the instantaneous effect of electricity. Of course electrons in a metal are not hard, round objects like peas. They influence their neighbours by electrical repulsion.

Gravitational models
We can picture a battery as a moving conveyor which raises electrical charges uphill to a higher level of electrical energy. Then as the charges travel round the rest of the circuit they run 'downhill', transferring energy to lamps and heaters.

We can draw a 'hill diagram' to show how a battery pushes the electric charges to a higher level of energy and how these charges then 'spend' the energy as they run down the various slopes to the bottom on their way round the circuit.
A ski-lift is a good model.

Water models
A model water circuit can also be helpful. We think of wires in a circuit as full of something that can be made to move (by a power supply or battery) just as water in a water circuit (such as a central heating system) can be made to flow by a pump.

This model fits with the idea of charge being a continuous, rather than a particulate, substance.
Students may already be familiar with the water cycle, and again this can be compared to an electric circuit. Solar radiation drives the cycle; a miller can transfer energy from the water as it runs downhill.

Fuel transport models
Some power stations are supplied direct by coal trains, direct from a coal mine. Coal may be burning within an hour of being cut underground.

In this representation the trucks represent coulombs of charge. They collect coal (energy resources) at the mine, and deliver it to the power station. Then return empty to the mine. If they didn't return we would soon be in trouble!
We can use a similar model in which little people run around the circuit carrying sacks of coal. They empty their sacks at one point and run on for a refill. Some students like such 'human' models but others may regard them as childish.

Squashed up particles
Electrons are charged particles, and they repel one another. This is how the push from the supply is transmitted round the circuit at a speed approaching the speed of light.

We can think of the energy carried by the electrons as being stored amongst them. They are squashed together, as if there were springs between them. Students should be familiar with electrostatic repulsion if they are to understand this. The higher the voltage, the greater the degree of squash, and the greater the tendency of the particles to burst out of the power supply.

Making use of models
For students to derive any benefit from these models they must feel that they are useful. They must not feel that they are just another bit of stuff which they must learn because the teacher says so.

One way to approach any of these models is to ask students to evaluate them in a systematic way. You might ask:

- What forms the circuit in this model?
- What goes round the circuit?
- What represents energy in the circuit?
- Where does the current collect energy?
- Where does it give up energy?
- In what ways is this model similar to your own ideas about electricity? In what ways is it different?
- Which model is better?

A number of accessible models mean that there are plenty of opportunities for students to raise questions and suggest testable hypotheses, as required at higher levels of science investigations.