**String loop model**

A group of students make a model of an electric circuit. They use a loop of string.

Anita moves the string round and round

Barry grips the string a little bit. Friction makes his hands heat up.



**To answer**

1. Which bit of the model is like:
   1. The electric current?
   2. The battery?
   3. The bulb?
2. Use the sting loop model to explain:
   1. what makes the bulb light up
   2. why, after a long time, the battery will stop working
   3. why a battery with a bigger voltage will make the bulb brighter
   4. why adding another battery would change the brightness of the bulb

*Physics > Big idea PEM: Electricity and magnetism > Topic PEM1: Simple electric circuits > Key concept PEM1.3: Voltage*

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| **Response activity** |
| **String loop model - voltage** |

**Overview**

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| Learning focus: | The voltage, of batteries and power supplies, is a measure of their ‘strength’. |
| Observable learning outcome: | * Describe the effect of different battery voltages on simple circuits. * Describe voltage, measured with a voltmeter, as the strength with which a battery can ‘push’ current around a circuit. * Use the idea of an ‘electrical push’ to explain the effect of different battery voltages on a circuit. * Apply the idea of an ‘electrical push’ to predict the effect of different series combinations of 1.5V batteries on simple circuits. * Calculate the total voltage of combinations of different batteries in series. |
| Activity type: | Response, clarifying, demonstration |
| Key words: | battery, current, voltage, volt |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Which is brightest?
* Diagnostic question: Current or voltage
* Diagnostic question: Combining 1.5V batteries
* Diagnostic question: Two different batteries

**What does the research say?**

Many researchers such as Driver et al (1994), Gott (1984) and 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 students to distinguish between: the current flowing through the circuit (that is conserved); the energy that is stored in the battery and then transferred elsewhere; and the voltage.

Driver et al (1994) suggest that to develop a good understanding of voltage, it is better, at this stage, to describe it as a measure of the strength of a battery’s ‘push’. In one study of 14-15 year old students in England, it was found that that 31% thought of voltage as something that flowed around a circuit (Shipstone, 1985). Driver *et al* (1994) note that embedding this clear distinction between current and voltage is a very important foundation for a clear understanding of electricity, and should be a focus of the learning at this stage.

Models are very useful to explain things we cannot see and there are many models for an electric circuit. Researcher shows that a mechanical model such as a string loop is best, because it helps students to recognise how all points in a circuit influence all others (Driver et al, 1994). Other types of models, often included in text books, have been shown to be much less effective with students.

**Ways to use this activity**

A group of four to six students stand in a circle; each person holds out both hands, palm upwards. A continuous loop of string passes from person to person, right around the circle. One person now acts as a ‘battery’, making the rope move slowly round, passing over everyone’s hands as it goes. Another person acts as a bulb (or other component) and squeezes their hands more tightly to slow down, and not to stop, the string.

With little or no introduction, ask ‘what has this to do with voltage?’

Use this as a starting point for a teacher led discussion to elicit key ideas and understanding about voltage. At this stage, students need to develop a model of the voltage as the strength of a battery’s ‘push’. The bigger the push in a particular direction around a circuit, the bigger the current in that direction.

Careful teacher questioning and discussion should lead quickly to an understanding that:

* The person pushing the string round is the battery
* The person gripping the string is a bulb
* The moving charges, or electric current, is the moving string
* Switching the battery for one with a bigger voltage pushes the current harder – so the charges move faster around the circuit and the bulb is brighter (friction of the string heats the hands more)
* Adding another identical battery the same way round pushes the current harder – so the charges move faster around the circuit
* Adding another battery the opposite way round pushes against the first battery – if they are the same size then the current stops, if one is bigger then it ‘wins’ and pushes a current round the circuit (which is reduced by the smaller battery)

The student worksheet ‘String loop model’ can be used to check that students can apply an understanding of this model to explain how a simple electric circuit works and how adding batteries can affect it.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For the class:

* Loop of thick string about 5m long (or a long string of beads such as those sold as Xmas decorations)

**Expected answers**

1 a. The moving string, b. Anita making the string move, c. Barry gripping the string

2 a. As Barry grips the string, friction makes his hands warmer and slows down the string as energy is shifted from the moving string to his hand. This is like the electric charge (current) moving through the bulb and making it hotter.

b. As Anita pushes the string energy is shifted from her chemical store to the moving string. If she does not eat then her chemical store will run out and she will be unable to move the string. Likewise, energy is shifted from the chemical store of the battery to the moving charges. After a while, the battery’s finite chemical store will run out.

c. A stronger person than Anita can push the sting harder. This will push the string more quickly through Barry’s hands and heat them up more. In a circuit, a battery with a bigger voltage pushes the electric charges harder. This makes them move faster through the bulb and energy is shifted more quickly from the moving charges to the bulb.

d. Adding another battery the same way round as the first one will add to its push, and the current will be bigger. If it is the opposite way round it will push against the first battery. The difference in how hard they push will determine the size of the current.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), from an adaptation by Mary Whitehouse (UYSEG) of an activity also included in the third edition of *Twenty First Century Science GCSE Physics* (OUP).

**References**

Driver R., Squires A., Rushworth P. and Wood-Robinson V. (1994). *Making sense of secondary science: research into children’s ideas* (pp.117-125). London and New York: Routledge.

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