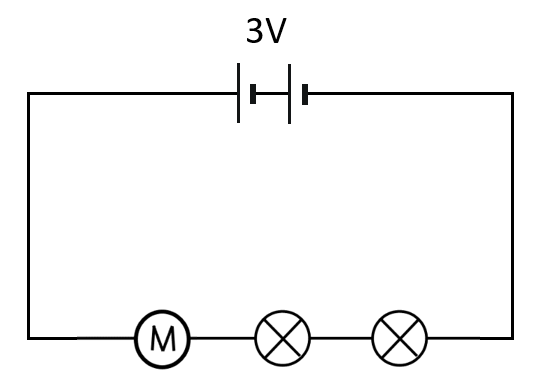
**A battery that works**

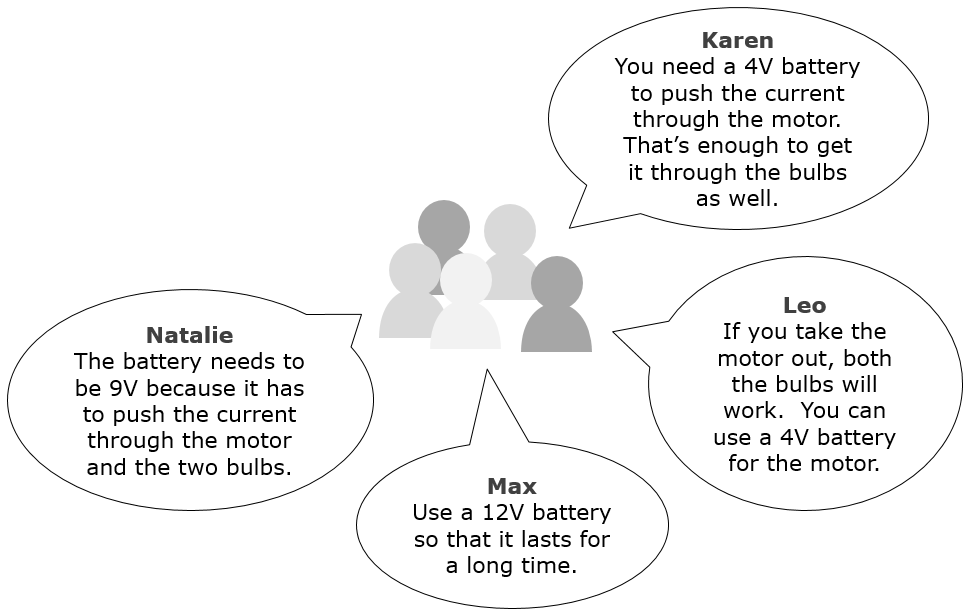
Jonathan made this circuit for his model car, and it didn’t work.

He has tested each component and each wire and they all work.

What should he do?

The motor has a 4 volt rating.

Each of the headlight bulbs has a 3 volt rating.



To do:

1. Who has the best solution for Jonathan? Explain your answer.
2. What mistakes do you think the other three students made? What would you say to them to help them to understand?

|  |  |
| --- | --- |
| **Karen**  You need a 4V battery to push the current through the motor. That’s not enough to get it through the bulbs as well. | **Leo**  If you take the motor out, both the bulbs will work. You can use a 4V battery for the motor. |
| **Max**  Use a 12V battery so that it lasts for a long time. | **Natalie**  The battery needs to be 9V because it has to push the current through the motor and the two bulbs. |

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| --- | --- |
| **Karen**  You need a 4V battery to push the current through the motor. That’s not enough to get it through the bulbs as well. | **Leo**  If you take the motor out, both the bulbs will work. You can use a 4V battery for the motor. |
| **Max**  Use a 12V battery so that it lasts for a long time. | **Natalie**  The battery needs to be 9V because it has to push the current through the motor and the two bulbs. |

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

|  |
| --- |
| **Diagnostic question** |
| **A battery that works** |

**Overview**

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| --- | --- |
| Learning focus: | Voltage is needed to push current through a component; and a particular voltage pushes just the right amount of current through a component for it to work well. |
| Observable learning outcome: | * Calculate the total voltage needed to push the ‘right amount’ of current through a combination of several components. |
| Question type: | Diagnostic, talking heads |
| Key words: | Voltage, current |

|  |  |
| --- | --- |
| **B** | **BRIDGING**  This diagnostic question probes understanding of ideas that are usually taught at age 14-16, to build a bridge to later stages of learning. |

**What does the research say?**

The majority of students confuse ideas of voltage and current, typically they think of voltage as part of the current. Often voltage is thought of as a substance that flows round the circuit and is used up, being shared out between different components (Shipstone, 1985).

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’ – and a bigger voltage gives a bigger ‘push’; or as a measure of how hard it is to push current through a component. The rating on a bulb or a motor, for example, tell us the strength of the push needed to make the component work as it was intended to.

Often students see the voltage rating on a component as the size of the battery it needs connecting to, with no reference to anything else in a circuit.

Students who hold a sequential model of a circuit (moving from the battery and then through each component in turn) may think of the components as a series of ‘hurdles’. If there is enough voltage to get over the biggest one, then there will be enough to get over each of the other ones as well. As Driver *et al* (1994) say, this is a “deep-seated notion with its roots in the ‘cause and effect’ of everyday experiences”. The use of a model to challenge and structure students’ thinking is an effective strategy in moving students towards the accepted scientific view of voltage, current and resistance.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

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 the 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.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

Natalie’s answer is correct.

**How to respond - what next?**

Natalie gives the accepted scientific view that the battery voltage needs to match the sum of the voltage ratings on the components.

Karen holds a sequential circuit model. She is imagining the ‘electricity’ moving round the circuit with enough voltage to get through each component in turn.

Leo thinks the battery needs to be the same as the voltage rating of each bulb, and ignores the fact that there are two bulbs – both affecting the circuit. His thinking is similar to Karen’s.

Max has perhaps understood that the voltage of a battery needs to be as big as the sum of the components’ voltage ratings, but appears to be thinking of the battery as a store of ‘voltage’. He has linked the voltage of the battery with the quantity of electricity that it contains.

If students have misunderstandings about the total voltage needed to push the ‘right amount’ of current through a combination of several components, it is useful to go back to the string loop model to challenge thinking and to tease out the correct scientific explanations. (Millar *et al* (2006) suggest that using the same model for electric circuits is more effective than trying to reinforce the learning with several different ones.)

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

* Adding extra components makes it harder for a battery to push the current round the circuit.
* All of the components in the loop add to the resistance against the battery’s push.
* If there are too many components, the battery is not strong enough to push current round (quickly enough).
* Swapping the battery for a more powerful one will push the current faster – and the current can be made big enough for everything to work.

Students could then be given the opportunity to express this in their own terms, or a chance to apply their scientific thinking to a new situation. In either case successful responses usually necessitate paired or small group activities and discussions, which encourage social construction of new ideas through dialogue.

**Acknowledgments**

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Images: UYSEG

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