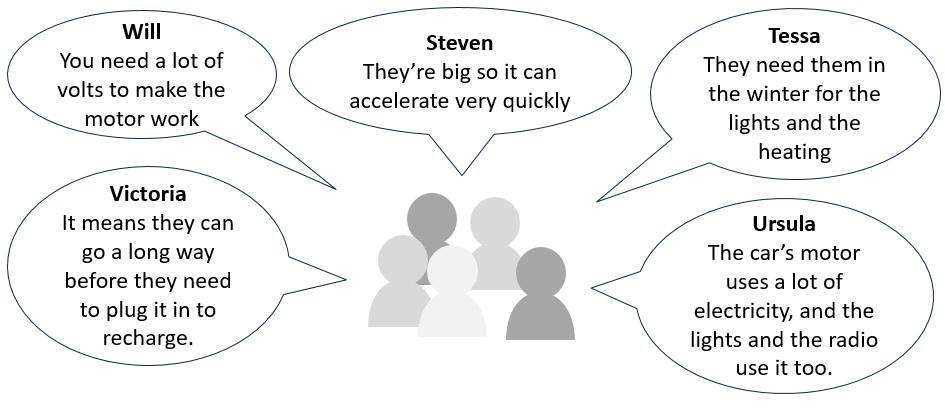
**Electric car**

The batteries in electric cars need to be very large.

These students are thinking about why the batteries in electric cars are so big.



1. Who has given a good reason why big batteries are needed?

*Explain your answer.*

1. Who has given a reason that is wrong?

*What would you say to them to help them to understand?*

|  |  |
| --- | --- |
| **Steven**  They’re big so it can accelerate very quickly. | **Tessa**  They need them in the winter for the lights and the heating. |
| **Ursula**  The car’s motor uses a lot of electricity, and the lights and the radio use it too. | **Victoria**  It means they can go a long way before they need to plug it in to recharge. |
| **Will**  You need a lot of volts to make the motor work. |  |

|  |  |
| --- | --- |
| **Steven**  They’re big so it can accelerate very quickly. | **Tessa**  They need them in the winter for the lights and the heating. |
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*Physics > Big idea PEM: Electricity and magnetism > Topic PEM1: Simple electric circuits > Key concept PEM1.3: Voltage*

|  |
| --- |
| **Diagnostic question** |
| **Electric car** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | In an electric circuit energy is shifted from the chemical store of a battery to the moving charge, and from the moving charge to circuit components. |
| Observable learning outcome: | * Use understanding of batteries and voltage to justify battery choice and limitations in real-life situations. |
| Question type: | Diagnostic, talking heads |
| Key words: | battery, chemical store, moving charge, energy |

|  |  |
| --- | --- |
| **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?**

To understand how a battery works in a circuit it is helpful to think of it as a chemical store (Millar, 2011). The chemicals in it are used up as they do work pushing electric charge around a circuit. Batteries with bigger voltages do work more quickly because they are pushing the electric charges harder. Most 11-14 year old students do not think of a battery in this way (Driver *et al*, 1994). In one study (Maichle, 1981) 340 out of 400 secondary school students in Germany thought of a battery as ‘storing a certain amount of electricity’ that was ready to flow round a circuit.

This misunderstanding can lead students to relating the physical size of a battery to its effect on a circuit. And this is perhaps reinforced by their experience of brighter torches using physically larger batteries.

**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**

Victoria has the best answer; Ursula and Tessa are correct too. Will and Steven have given wrong answers.

**How to respond - what next?**

Victoria has linked the size of the battery with the length of time it work.

Ursula and Tessa have understood that the car will use a lot of electricity which will use up the chemical store more quickly.

Steven is likely to be thinking that the battery is a store of ‘electricity’ and because there is a big store it can do things quickly.

Will is confusing the size of the battery with its voltage.

If students have misunderstandings about why the batteries in an electric car need to be so large, it may be useful 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:

* The person being the battery is pushing the string round and the string (moving charge) is not pouring out of the battery.
* That the person who is the battery can only push so hard (no matter how much they have eaten)
* That after (a very long) time the battery will stop pushing because it will run out of food / fat / ‘chemicals’ that its muscles need.
* If the battery was shifting energy very quickly, it would run out of its chemical store more quickly.
* If the battery had more energy at the start it would take longer to run out of chemicals.

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.

*Extra information for teachers*

The reason brighter torches often have larger batteries is that they use a different bulb that needs a bigger current to work. To push the bigger current round the circuit, the chemical store in a battery will do work more quickly and its chemicals too will run out more quickly. Physically larger batteries are used because they have a bigger chemical store which means the torch won’t run out too quickly.

**Acknowledgments**

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**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.

Maichle, U. (1981) ‘Representation of knowledge in basic electricity and its use for problem solving’, in Jung, W., Pfundt, H. and von Rhoneck, C. (eds), *Proceedings of the International Workshop on Problems concerning students’ representation of physics and chemistry knowledge*, 14-16 September, Pedagogische Hochschule, Ludwigsburg, pp174-93.

Millar R., Leach J., Osborne J. and Ratcliffe M. (2006). Improving Subject Teaching, Lessons from research in science education. London and New York: Routledge.

Millar, R. (2011). ‘Energy, in Sang, D. (Ed), *Teaching secondary physics* (pp. 1-48). London: Hodder Education.