**How fast are they going? (4)**

These questions are about two cars, one red and one blue, travelling at constant speed along a track.

A screenshot of a computer

Description automatically generated with low confidenceThe picture shows the two cars. They start and stop at the same time.

Some students are talking about what happens when two cars move at a constant speed for the same amount of time, and the blue car moves a bigger distance.

**Sumaya:** The blue car has the highest speed because it travels further in the same time.

**Malachi:** Both cars have the same speed at the end because they start and finish at the same time.

**Robyn:** You can’t tell which car is going fastest because they don’t travel the same distance.

**Luka:** The blue car has the highest speed. It is ahead of the red car all the way.

**To answer:**

1. Who do you think is right about the speed of the cars?

*Explain your answer.*

1. Why do you think the other students are wrong?

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

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*Physics > Big idea PFM: Forces and Motion > Topic PFM4: Describing and calculating motion > Key concept PFM4.1: Velocity*

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| **Response activity** |
| **How fast are they going? (4)** |

**Overview**

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| Learning focus: | Velocity and displacement are vector quantities. Velocity measures by how much displacement changes in a given time interval. |
| Observable learning outcome: | Explain the difference between distance and displacement, and between speed and velocity. |
| Question type: | Talking heads |
| Key words: | Velocity, speed, distance, time |

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| **P** | **PRIOR UNDERSTANDING**  This diagnostic question probes understanding of ideas that are usually taught at age 11-14, to aid transition from earlier stages of learning. |

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

* Diagnostic question: Going in the right direction
* Diagnostic question: Setting it out

**What does the research say?**

Students have a somewhat undifferentiated understanding of the kinematical terms speed, velocity and acceleration and often merge them together into a general idea of ‘motion’. They may conflate words that have related meanings, such as distance and displacement, or speed and velocity, not always realising the important differences between them (de Winter and Hardman, 2021). Although these terms are connected, the differences matter, and teachers should use terms carefully, taking care to be precise in their use of language. Before developing ideas about velocity, students need to have a sound grasp of the concept of speed.

Students may have an intuitive understanding of speed, and although they understand that it involves both distance and time, they do not always understand it as a ratio (Trowbridge and McDermott, 1980). Although they may be able to correctly identify which car is going faster, they may not correctly identify the reason, and may think separately about the distance and the time.

Students may know that speed is “distance over time”, but may not understand the significance of the word ‘over’ and think of it as meaning ‘during’ (Trowbridge and McDermott, 1981), so that speed becomes the distance travelled during an interval of time. Whilst this idea is quantitatively correct, students may not understand the qualitative nature of the relationship.

Students sometimes believe that objects have the same speed at the moment of passing (Trowbridge and McDermott, 1980), and confuse position and speed.

**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.

Use this question in conjunction with the other ‘How fast are they going?’ response activities to explore possible misconceptions with ideas of speed before developing ideas about velocity.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in 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**

Sumaya is correct.

Luka has identified correctly which car is going fastest, but for the wrong reason. He has confused position with speed and thinks because the blue car is ahead at all times it must be going fastest.

Malachi thinks that the time of travel corresponds to speed so that as both cars take the same time for their journeys, they are travelling at the same speed.

Robyn is not able to work out the speed from the information given – she may not understand that speed is the ratio of distance to time, or may not know the equation used to work out speed.

**Acknowledgments**

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Images: Simon Carson (UYSEG)

**References**

de Winter, J. and Hardman, M. (2021) *Teaching secondary physics.*

Trowbridge, D. E. and McDermott, L. C. (1980) Investigation of student understanding of the concept of velocity in one-dimension, *American Journal of Physics*, 48(12), pp. 1020–1028. doi: 10.1119/1.12298.

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