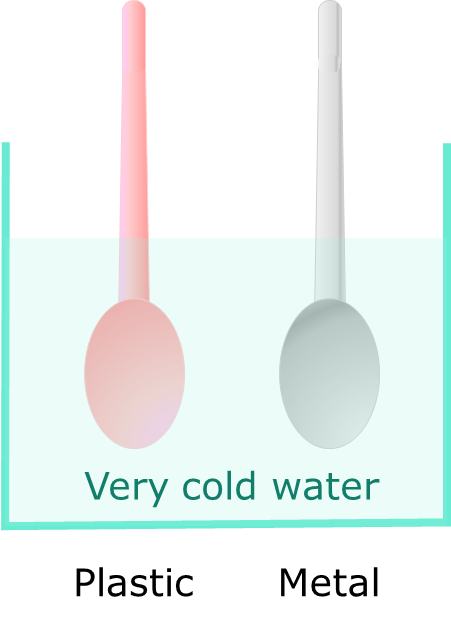
**Cold spoons**

These two spoons have been dipped into some very cold water.

They have been left in the water for a long time.



These statements are about the spoons.

For each statement about them, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | The metal spoon feels colder. |  |  |  |  |
| **B** | The plastic spoon has a higher temperature. |  |  |  |  |

*Physics > Big idea PMA: Matter > Topic PMA3: Energy of moving particles > Key concept PMA3.1: Transfer of energy by conduction*

|  |
| --- |
| **Diagnostic question** |
| **Cold spoons** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Energy is transferred through a solid away from regions of higher temperature as its particles are caused to vibrate more vigorously. |
| Observable learning outcome: | Explain why different objects in thermal equilibrium feel hotter or cooler to touch. |
| Question type: | Confidence grid |
| Key words: | Thermal equilibrium, temperature |

**What does the research say?**

It is common for students to *not accept* that different objects are at the same temperature as each other if they are left in contact with the same surroundings for a long time (Thomaz et al., 1995; Hatzikraniotis et al., 2010). Hatzikraniotis et al. (2010) found that just over 40% of 13- to 14-year-olds (n=24) did not understand that objects in thermal equilibrium all have the same temperature. Understanding the concept of thermal equilibrium is central to understanding other heat and temperature concepts (Thomaz et al., 1995).

Students may link their perceived temperature of an object to whether it feels warm or cold to the touch, for example that metal is colder than plastic when both are at room temperature (Engel Clough and Driver, 1985; Thomaz et al., 1995). In a study of 12- to 16-year-olds (n=84), Engel Clough and Driver (1985) found just 6% were able to explain correctly why metal spoons felt colder to the touch than plastic spoons at the same temperature. 25% said it was because metals let ‘heat’ in or out more easily and 5% that they attracted or absorbed coldness. Pathare and Pradhan (2010) found that this idea persisted even amongst a few undergraduate physics students.

When asked to explain why the metal parts of handlebars felt colder than plastic parts in cold, frosty weather, Engle Clough and Driver (1985) found that 23% of 12- to 16-year-olds (n=84) explained this using the misunderstanding that metals attract or absorb cold more easily. ‘The direction of conduction of heat in relation to the human body appears to influence thinking; quite simply students find it difficult to think of conduction of heat when they feel cold’ (Engel Clough and Driver, 1985).

McLure, Won and Treagust (2020) found that a thinking frames approach to understanding the concept of why conduction away from the body caused object to feel cold was particularly successful, and significantly improved students understanding both immediately and in the longer term. The thinking frames approach used predict, explain; observe, explain activities to engage students in focussed small group discussions, in order to support the construction of a scientific understanding.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Statement A is right and statement B is wrong.

**How to respond - what next?**

Answer A is correct because when the hand heats the metal, the metal’s good thermal conductivity allows energy to transfer quickly from the hand. Metal ions made to vibrate more quickly by the hand very quickly transfer vibrations on to metal ions throughout the spoon. The vigour of the vibrations of the metal ions in contact with the hand do not increase enough to raise their temperature sufficiently to feel warm to the touch.

The lower thermal conductivity of the plastic spoon means the heating from the hand can increase the temperature much more locally so, at the point of contact, the plastic feels warm. The rest of the plastic spoon is at the same temperature as the metal spoon, so answer B is wrong.

If students have misunderstandings about why different objects in thermal equilibrium feel hotter or cooler to touch, it can help to discuss with students the temperature of their own hands and the temperature to the object that they are touching, in order to help them to think about the situation in a scientific way. The temperature of the palm of a hand touching a cold metal spoon is likely to be around 30oC, much warmer than the spoon.

Focused small group discussions can then support the social construction of a scientific understanding through dialogue. The following BEST ‘response activities’ use this strategy in a way that McLure, Won and Treagust (2020) found to be particularly successful in helping students understand the concept of why conduction away from the body causes an object to feel cool. They could be used in follow-up to this diagnostic question:

* Response activity: Thermal equilibrium
* Response activity: Melting ice

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), from a question in a paper by Thomaz et al. (1995).

Images: by Peter Fairhurst (UYSEG).

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