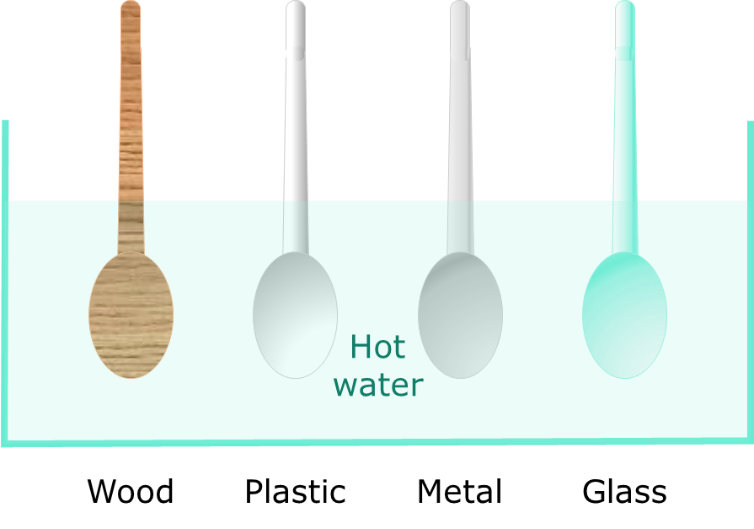
**Heating spoons**

Energy can be transferred through a spoon by thermal conduction.

These spoons are made from different materials.

Thermal conduction is faster in some materials and slower in others.



These statements are linked to thermal conduction in different materials.

*For each statement, 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** | Temperature of a material increases as it fills with heat. |  |  |  |  |
| **B** | Particles in a spoon with bigger vibrations make the particles next to them vibrate more vigorously. |  |  |  |  |
| **C** | There is no thermal conduction through a plastic spoon. (Plastic is an insulator.) |  |  |  |  |
| **D** | Our skin can detect the vibrations of particles that are too small to see under a microscope. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Heating 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: | Describe the mechanism of thermal conduction that can occur in all solids. |
| Question type: | Confidence grid |
| Key words: | Heat, energy, particle, vibrate |

|  |  |
| --- | --- |
| **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. |

**What does the research say?**

The notion that heat and cold are material substances that can flow from one place to another seem to be both common and persistent (Engel Clough and Driver, 1985; Hatzikraniotis et al., 2010; Thomaz et al., 1995). Engel Clough and Driver (1985) found that almost all 12- to 16-year-olds understood that ‘heat’ travelled through metals, but often described heat flowing rather than the actual mechanism. Hatzikraniotis et al. (2010) reported that the majority of 13- to 14-year-olds (n=24) described thermal conduction as the flow of hot particles. In their study in Portugal, Thomaz et al. (1995) similarly found that before teaching, 42% of 14- to 15-year-olds (n=79) wrongly thought of ‘heat’ (or ‘cold’) as a substance.

**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**

Statements B and D are right; statements A and C are wrong.

**How to respond - what next?**

Students who think that statement A is correct are likely to be thinking of energy or heat as a fluid that flows through a material. This is a common misunderstanding of students throughout secondary education.

In spoons made of any material, the particles are bonded together in a solid form. When one vibrates more vigorously than a neighbouring particle the latter is shaken and made to vibrate more vigorously itself. Through this mechanism the particles along the length of any solid can be made to vibrate more vigorously. This means that statement C is wrong because vibrations can be passed on from particle to particle in a solid insulator. In a solid insulator the bonds are less rigid than in a good conductor and pass on the vibrations with less efficiency.

The sensation of hotness that is felt when touching a warm object originates from the vibrations of its particles. Although we cannot detect individual vibrating particles, we can easily detect them *en masse*.

If students have misunderstandings about the mechanism of thermal conduction that can occur in all solids, it can help to give them the opportunity to test out their explanations through focused small group discussions, which encourage social construction of new ideas through dialogue. Asking them to model thermal conduction and to apply their understanding to new examples helps check and consolidate their scientific understanding. The following BEST ‘response activities’ could be used to do these things, in follow-up to this diagnostic question:

* Response activity: Feel the heat
* Response activity: Along the line

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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Hatzikraniotis, E., et al. (2010). Students' design of experiments: an inquiry module on the conduction of heat. *Physics Education,* 45 (4)**,** 335-344.

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