**Warm and cold**

Some objects feel warm to the touch.

Other objects feel cold to the touch.



These objects have been in the same place for several hours.

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 glass feels cooler than the book. |  |  |  |  |
| **B** | The orange has a higher temperature than the mug. |  |  |  |  |
| **C** | The temperature of each object is the same. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Warm and cold** |

**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).

**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 A and C are right; and statement B is wrong.

**How to respond - what next?**

An understanding of thermal equilibrium is essential if students are to be able to explain why objects with different thermal conductivities feel warmer or cooler to the touch.

All of the objects in this question are at room temperature and are cooler than the hand, perhaps by about 15oC, but they do not all *feel* to be at the same temperature. It is a common misunderstanding for students to interpret the sensation they feel as hotness or coolness as temperature.

The glass feels cooler than the book because glass is a better thermal conductor than paper. This means that heating from the hand warms the *whole* of the glass and this means that the temperature of the glass rises slowly.

The orange, book and plastic box all feel warmer than either the mug or glass because they are bad thermal conductors. Heating from the hand warms only the small part of the object that it is touching and the temperature of that part quickly increases and feels warm. The temperature of the rest of the object remains at or very close to room temperature.

If students have misunderstandings about why different objects in thermal equilibrium feel hotter or cooler to touch, it can help to give students the opportunity to feel and to measure the temperature of different materials that are in thermal equilibrium, in order to challenge any misunderstandings and to prove that they are all at the same temperature as each other.

Focused small group discussions can support the social construction of a scientific understanding through dialogue. Giving students the opportunity to apply their understanding of why objects at the same temperature can feel warmer or cooler to new situations can consolidate their understanding.

The following BEST ‘response activities’ could be used to do these things, in follow-up to this diagnostic question:

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

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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

Thomaz, M. F., et al. (1995). An attempt to overcome alternative conceptions related to heat and temperature. *Physics Education,* 30 (1)**,** 19-26.