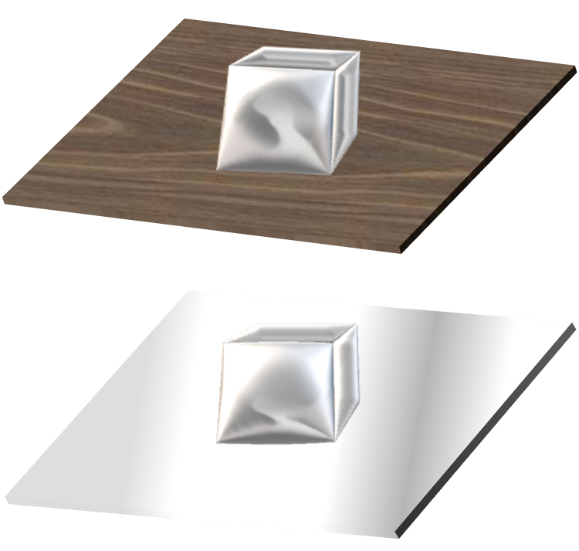
**Melting ice**

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Two pieces of ice are taken out of a freezer at the same time.

They are the same size as each other.

One is placed on a piece of wood, the other on a piece of metal.

They are left to melt next to each other.

**Predict**

How quickly do you think each piece of ice will melt?

Which will melt the most quickly?

**Explain**

Why do you think the pieces of ice will melt like this?

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| --- |
| **Observe the ice at intervals of ten minutes.** |

**Observe**

Record a description of each ice cube at intervals of ten minutes.

**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more clearly.

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

|  |
| --- |
| **Response activity** |
| **Melting ice** |

**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. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | Thermal equilibrium, temperature |

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

* Diagnostic question: Warm and cold
* Diagnostic question: Handlebars
* Diagnostic question: Cold spoons

**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 activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now carry out the practical, or watch a demonstration. You will need to decide whether it is better for each group to carry out the practical and risk some unexpected observations, or to demonstrate the activity so that everyone *observes* the same thing.

*As each ice cube needs be left at room temperature and observed at ten minute intervals, this activity needs to be set up at the start of the lesson and observed whilst students engage with other activities. The final explanations should be completed at the end of the lesson.*

*This activity could work well as a demonstration with a visualiser.*

*The BEST response activity PMA3.1: Thermal equilibrium has the same objective as this activity and could be completed during the same lesson.*

After the practical each group should be given the opportunity to change, or improve their explanation. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*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 a 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.

**Equipment**

For the class:

* Two ice cubes of the same size.
* Wooden plate
* Metal plate
* Timer

**Technician notes**

The two plates should be as similar as possible to each other in terms of shape and dimensions.

This works better if the ice is taken out of the freezer a little before the lesson, so that the ice is just showing the first visible signs of melting whilst it remains in the ice tray.

**Health and safety**

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

The ice on the metal plate melts more quickly than the ice on the wooden plate.

The wood feels warmer than the metal because it is a poor thermal conductor. This means that when we touch it the wood immediately in contact with our fingers can quickly heat up and feel warm whilst the rest of the wood remains at room temperature. For this reason the ice on the wooden plate is not warmed from the bottom through the wood, as the wood underneath it remains cold.

By contrast the metal plate is a good thermal conductor and because it is warmer on the bottom than on the top, where it is in contact with the ice, it transfers energy from the room to the ice (from where it is warmer to where it is cooler). This means that the ice on the metal plate experiences more warming than the ice on the wooden plate.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), from an idea by McLure et al. (2020).

Images: Peter Fairhurst (UYSEG).

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