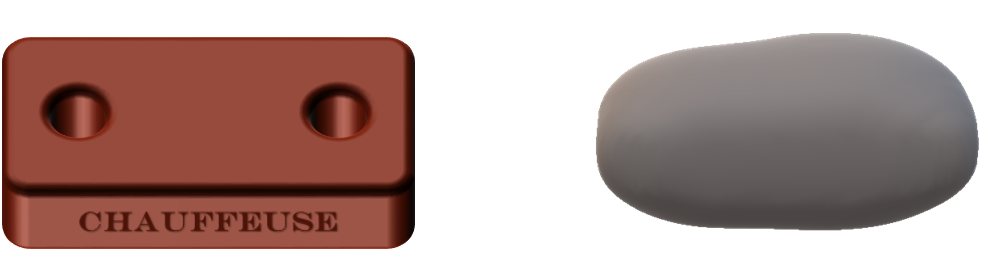
**Bed warmers**

In the olden days bricks or rocks were often heated in an oven and put into a bed to warm it up.



A rock with the same mass as the brick.

A bed warming brick

The brick and rock are both heated to 160oC in an oven.

The brick heats up faster than the rock.

These statements are about the brick and rock.

*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** | The brick stays hot for longer. |  |  |  |  |
| **B** | The brick has a higher specific heat capacity. |  |  |  |  |

*Physics > Big idea PMA: Matter> Topic PMA3: Energy of moving particles > Key concept PMA3.2: Specific heat capacity*

|  |
| --- |
| **Diagnostic question** |
| **Bed warmers** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Specific heat capacity is the amount of energy added to the thermal store of a material in order to increase the temperature of 1kg of that material by 1oC. |
| Observable learning outcome: | Explain why a material’s specific heat capacity affects the rate at which its temperature will change as its thermal store gains or loses energy. |
| Question type: | Confidence grid |
| Key words: | Energy, temperature, mass, specific heat capacity, thermal store |

**What does the research say?**

Herrington (2011) suggests the traditional method of teaching specific heat capacity, which involves learning the related definitions and equations and using equations to determine the specific heat capacity in a laboratory setting contributes to confusion about specific heat capacity. Although students are often able to calculate values with the equation, they often do not often understand what specific heat capacity tells us about a material. Instead it can be more effective to introduce students to the concept of heat capacity and to guide them to make connections to their own personal experiences before introducing definitions and equations.

One way to think about specific heat capacity is as a measure of how hard it is to change the temperature of a material. For two objects of the same mass, the one with the bigger specific heat capacity will be harder to warm up as it requires more energy to increase its temperature by 1oC. The same object will also be more resistant to cooling down, as it needs to transfer more energy to its surroundings in order to reduce its temperature by 1oC. Adadan and Yavuzkaya (2018) found that 35% of 13- to 16-year-olds (n=518) had the misunderstanding that objects that warm up readily retain their temperature better than objects that are harder to heat up.

**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**

Both statements are wrong.

**How to respond - what next?**

The brick heats up faster because it has a lower specific heat capacity than the rock and they both have the same mass. Less energy from the oven needs to be transferred into the thermal store of the brick to increase its temperature. So at 160oC, the brick has less total energy in its thermal store than the rock does in its thermal store, and the brick’s temperature (assuming energy radiates from both objects at the same rate) will go down more quickly than the rock’s.

A significant number of students are likely to think that the brick will stay hot for longer because it heated up more quickly. A naïve understanding is that objects that heat up quickly do so because they ‘attract heat’. Some students who think this may still be thinking of ‘heat’ (energy) as some sort of substance that flows and that it is easier for it to flow into, and remain within, some objects.

It is also likely that some students will think of specific heat capacity as a measure of how easily an object heats up or cools down. In fact the opposite is true, but in addition to specific heat capacity the mass and temperature change of the object also need to be taken into account. At this stage comparing similar temperature changes for objects with the same mass can help develop a deeper understanding of what it means for an object to have a bigger, or smaller, specific heat capacity.

If students have misunderstandings about why a material’s specific heat capacity affects the rate at which its temperature will change as its thermal store gains or loses energy, it can help challenge thinking by giving students the opportunity to time how long it takes to heat a fixed mass of cooking oil and water to a particular temperature, using the same heat source each time. And then to measure the time it takes the temperature of each to fall by a certain amount, which is straightforward if a water bath is used to achieve equal starting temperatures. As cooking oil has a specific heat capacity less than half that of water, it should heat up and cool down more than twice as quickly.

Using this activity to give students the opportunity to apply the scientific thinking to a new situation is usually most successful if it is followed by paired or small group discussions focused on explaining the observations in terms of the specific heat capacity of each substance, which encourages social construction of new ideas through dialogue.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Hot water bottle

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Adadan, E. and Yavuzkaya, M. N. (2018). Examining the progression and consistency of thermal concepts: a cross age study. *International Journal of Science Education,* 40 (4)**,** 371-396.

Herrington, D. G. (2011). The heat is on: an inquiry-based investigation for specific heat. *Journal of Chemical Education,* 88(11)**,** 1558-1561.