4. Keeping things warm or cold

1½ hours activity

Children set up their own investigation to compare the thermal insulating properties of polystyrene, expanded polystyrene and metal.

OBJECTIVES

- Compare and group together everyday materials on the basis of their properties, including their thermal conductivity
- Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials, including metals, wood and plastic
- Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary

RESOURCES

(per group)

- Activity Sheet A4a or A4b/c[1]
- Activity Sheet A4d/e
- Activity Sheet A4f or A4h[2]
- Metal can, (with lid safely removed)
- Expanded polystyrene cup
- Polystyrene cup
- Milkshake or drinks lids with '+' cut for a straw (or card discs to fit the cups with a hole for the thermometer)
- 3 thermometers
- Stop-watch or 2- and 5-minute egg timers
- Source of hot water
- 2-litre plastic bottle

Prior to the cold water activity the teacher will need to half-fill a 2-litre plastic bottle with water and leave in a freezer overnight. The bottle is taken out of the freezer about 1-2 hours before the lesson begins and filled up with water. The bottle is left to stand so that the temperature of the water falls to about 3 °C. The water is then ready for use.

1 This will depend on whether an open-ended or more structured approach is used.
2 This will depend on the choice of bar graph the child is to produce.

CARRYING OUT THE ACTIVITY

Sheet A4a provides the stimulus for discussion on fair testing if the teacher wants to adopt an open-ended approach to the activity. This sheet shows unfair test situations using containers of different sizes as well as differing amounts of water and ice-cubes. Guess-work has been used rather than measuring the temperature of the water or the time passed.

The children then plan their own investigation, and are encouraged to think about which factors to keep the same and what to measure. They can control the size of the container (as closely as possible) and the amount of water. They can measure the temperature of each cup of water and use the same time intervals between each measurement.

Alternatively, Activity Sheet A4b provides a structured method for carrying out the test, applying the above criteria of measurement and fair testing. The equipment is set up as shown here.

The children can organise most of the activity but **the teacher must pour the hot water into each container.** The water should be no hotter than 60 °C. 100 ml is a suitable quantity of water.

N.B. Ensure that the start temperatures in each cup are as close together as possible. Regulate temperatures by mixing hot and cold water together.

As the temperature of the water is taken every two minutes, children work in groups of three (see Appendix 2 for a sample set of results). Each child is then responsible for reading and recording the temperature from one thermometer. *They should allow a few seconds for the thermometer reading to adjust to the water temperature before reading the scale.*

The children could be challenged to estimate the next thermometer reading (whilst waiting for the end of a time interval) and attempt to become more accurate with each estimate they make.

Safety note

The thermometer should be removed between readings to minimise the possibility of the cups being knocked over.

The results are recorded on Activity Sheet A4d, and each child could then complete a graph (once the temperature measurement is completed) using Activity Sheet A4f or A4h. For sheet A4f, children mark and colour in the bar for that temperature. The extension of this is to only plot temperature points on each thermometer template and then join these to produce a line graph. Different coloured lines could be drawn for easy comparison on the same graph.

To obtain the results for the cold water experiment the children can repeat the procedure. This time they use 100 ml of iced water from the 2-litre plastic bottle. These results are recorded on Sheet A4e. Alternatively the class could be split into two, half the groups using hot water and the others using cold.

If a clock or watch with an alarm is available the children could continue with other work (e.g. the temperature graph) during the 5 minute intervals.

N.B. The bar chart sheets will need adapting for the different time scales used in this test.

The teacher encourages the children to offer explanations of their results during discussion. The children are asked to think about the way in which materials reduce the movement of heat (heat transfer). They should understand that the insulator prevents the heat energy escaping. The teacher should discourage the idea that 'cold' is entering the cup, as this is incorrect.

QUESTIONS FOR THINKING

- Can we use the final temperatures of the water to find out which cup was the best insulator?
- Were the plastics better insulators than the metal?
- Which plastic was the best insulator?
- Why is there a difference between the insulating properties of the two plastics?

BACKGROUND INFORMATION

The change in temperature can be calculated by subtracting the final temperature from the start temperature. The change in temperature can be thought of as an indication of the amount of heat that has 'moved' from the water. A simplified explanation is that the heat moves from the water through the cup and to the cooler surrounding air. Similarly with the cold water, the heat moves from the warmer surrounding air, through the cup and into the water.

Air is trapped inside expanded polystyrene. A simplified explanation for air being a very good insulator is that the particles in air are far apart and the heat is not readily passed from one particle to another. Therefore its presence in the expanded polystyrene gives it greater insulating properties than the unexpanded variety. Similarly, metals are poor insulators as the particles in them are close together and the heat is readily passed from one particle to another.

Appendix Two

Example Temperature Record Sheet

Keeping water warm

Temperature in °C taken every 2 minutes										
Cup	Start	2	4	6	8	10	12	16	18	20
Metal	63	60	57	55	53	50	48	45	44	43
Polystyrene	64	60	58	55	53	52	52	48	47	45
Expanded polystyrene	65	63	61	59	58	56	55	53	51	50

Which cup kept the water warmest? expanded polystyrene

Keeping water cold

Temperature in °C taken every 5 minutes										
Cup	Start	5	10	15	20	25	30	35	40	45
Metal	3	5	6	7	8	9	10	10	11	12
Polystyrene	3	4	5	7	7	8	9	10	11	12
Expanded polystyrene	3	4	4	5	5	6	7	7	8	9

Which cup kept the water coolest? expanded polystyrene