**Getting warm**

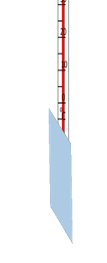
A piece of card (at room temperature) is fixed to a thermometer.

An electric heater heats the card for two minutes.

**Predict**

The same piece of card (at room temperature) is turned so it is at an angle to the heater.

It is heated for two minutes.

Will it reach the same temperature as before?

**Explain**

Why do you think this will happen?

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| **Carry out the investigation** |

**Observe**

Record the highest temperature of the card each time.

**Explain**

Were your prediction and explanation correct?

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

*Physics > Big idea PES: Earth in space > Topic PES2: Earth and Sun > Key concept PES2.1: Days and seasons*

|  |
| --- |
| **Response activity** |
| **Getting warm** |

**Overview**

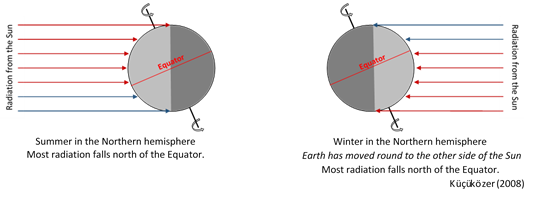
|  |  |
| --- | --- |
| Learning focus: | The temperature is higher in the summer because the tilt of the spinning Earth increases the length of a day and increases the heating effect of the Sun’s radiation. |
| Observable learning outcome: | Explain why the angle of the Sun changes the effect of its heating. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | Radiation, heating, heat radiation |

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

* Diagnostic question: Heating the towel

**What does the research say?**

In the summer one reason temperatures are higher is because the part of the Earth experiencing summer is tilted towards the Sun. This means the Sun is higher in the sky and the radiation from it is spread out over a smaller area of land giving a bigger heating effect. Ojala (1992) suggested representing the uneven distribution of the Sun’s radiation over the Earth’s surface with a diagram that shows how equal amounts of radiation spread. Küçüközer (2008) used a computer simulation to show what proportion of all radiation reaching the Earth fell above or below the equator during the summer and the winter.



In text book diagrams, rays representing radiation from the Sun reaching the poles appear significantly longer than those reaching the equator. Such diagrams can reinforce the misunderstanding that it is warmer in the summer because we are closer to the Sun. When students encounter these diagrams for the first time they often do not have an accurate understanding of scale and do not realise that the differences in distances here are too small to make a noticeable difference to temperature (Ojala, 1992; Ojala, 1997). Ojala also found that the common practice of showing all four seasons on one diagram caused confusion and suggested using a separate diagram for each season.



The most common reason students (wrongly) give for why it is warmer in the summer is the Earth being closer to the Sun at that time (Allen, 2014; Driver et al., 1994; Baxter, 1989). Bakas and Mikropoulos (2003) found that Greek students aged 11-13 (n=102) were more likely to explain that higher temperatures in summer are caused by the Sun being higher in the sky, or because the days are longer, but without explaining the cause of these phenomena.

Constructivist teaching strategies that challenge student misunderstandings were shown to significantly improve knowledge about the causes of seasons (Trumper, 2006) and elicit longer retention of the scientific concepts (Tsai and Chang, 2005).

**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.

* The card is fixed onto the thermometer with a small piece of Blu-tack. The bulb should be touching the centre of the card.
* The thermometer is held in a clamp and stand so that the card is at a height that puts it near the centre of a radiant heater.
* The heater is turned on and allowed to heat up away from the thermometer.
* A point about 5 cm in front of the heater is marked (measure with a ruler).
* The thermometer is moved to the marked position and the timer started.
* After 2 minutes the temperature on the thermometer is read.
* The card is allowed to cool and the measurement repeated with the card at an angle of about 45o to the heater.

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 each student/pair/group:

* Radiant heater (A 60W filament bulb can be used instead)
* Thermometer (0-100 oC)
* Piece of card
* Blu-tack
* Clamp and stand
* Timer

**Technician notes**

Use a piece of thin card approximately 5cm x 5cm. White card will be fine, but black absorbs heat more quickly and gives a larger increase in temperature.

The distance between the card and the heater should be enough to heat the card by about 30oC in two minutes. The exact distance will depend on the heater.

**Health and safety**

Heaters (or light bulbs) get hot.

Mains electricity is used, plugs need to be checked for damage and for loose wires before use.

Glass thermometers can easily roll off tables.

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 card at an angle will not heat up as much. (At 45o the card’s temperature rises by about 70% of the increase in temperature of the card facing the heater.)

Less heat radiation from the heater will hit the card at an angle so there is less heating. Looking from the heater, the card at an angle takes up less space.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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