ACTIVITY: Temperature

ACTIVITY OVERVIEW

'Hotness' and 'coldness' are relative terms. Compared to a cup of hot chocolate, a cup of tap water feels cold, but to a polar bear rolling about on the Arctic ice sheet, both drinks would probably feel warm. While the polar bear may not be too fussy about the temperature of either beverage, our everyday lives would be in chaos if we didn't rely on objective ways of describing things like temperature, time, mass, length, and height.

In this activity, students explore how applying numbers to the concept of 'hotness' and 'coldness' helps us quantify, compare, and find explanations to observations. Younger students can use this exercise to enhance their understanding of 'Number and Algebra', while older students work towards achieving skills in the 'Statistics and Probability' component of the Mathematics curriculum as they collect, interpret, and represent their own data set.

SYNOPSIS

In this activity, students explore how applying numbers to the concept of 'hotness' and 'coldness' helps us quantify, compare, and find explanations to observations. Younger students can use this exercise to enhance their understanding of 'Number and Algebra', while older students work towards achieving skills in the 'Statistics and Probability' component of the Mathematics curriculum as they collect, interpret, and represent their own data set.

Foundation – Year 2

- F: Connect number names, numerals, and quantities, including zero - initially up to 10 and then beyond. (VCMNA070)
- F: Use direct and indirect comparisons to decide which is longer, heavier, or holds more, and explain reasoning in everyday language.(VCMMG078)
- Y1: Recognise, model, read, write, and order numbers to at least 100. Locate these numbers on a number line. (VCMNA087)
- Y2: Identify a question of interest based on one categorical variable. Gather data relevant to the question. (VCMSP126)
- Y2: Create displays of data using lists, tables and picture graphs and then interpret them. (VCMSP128)

Years three – four

- Y3: Collect data, organise into categories and create displays using lists, tables, picture graphs and simple column graphs, with and without the use of digital technologies. (VCMSP149)
- Y4: Construct suitable data displays, with and without the use of digital technologies, from given or collected data. Include tables, column graphs and picture graphs, where one picture can represent many data values. (VCMSP179)
- Y3-4: Heat can be produced in many ways and can move from one object to another. A change in the temperature of an object is related to the gain or loss of heat by the object. (VCSSU063)

Year five – six

- Y5-6: Pose questions and collect categorical or numerical data by observation or survey. (VCMSP205) (VCMSP237)
- Y5-6: Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies. (VCMSP206)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

Are all things equally hot? Or not? How does heat interact with matter? Students seek different temperatures in this activity and compare the amount of heat found in or on different objects.

Materials for 30 students (working in pairs)

- 15 x Thermometers* (e.g. alcohol (spirit) or digital)
- Worksheet

*Choose durable, mercury-free thermometers with plastic backings where possible.

Instructions

1. Elicit prior knowledge from students.

   What do they know about heat? How do children determine hotness or coldness? What are some examples of hot or cold things? Could there be an instance when the same object feels hot to one person and cold to another? What are advantages to using temperature to describe how 'hot' an object is?

2. Teacher explains how a thermometer works.

3. Teacher explains how to use a thermometer*.

   Alcohol (spirit) thermometer: Place the bulb into the liquid or onto the surface of an object carefully. Watch the liquid rise or fall as it either expands or contracts in volume. The number on the stem of the thermometer corresponding to where the liquid stops is the temperature. Record the temperature.

   Digital thermometer: Switch on the thermometer. Place the sensor on the object and wait for an indication that the temperature has been recorded. This can be in the form of light or a sound.

   *These are generic instructions. Follow instructions as described in the user manual for the specific thermometer.

4. Students take the temperatures of different places using a thermometer

   - Exposure (e.g. in the sun, in the shade, inside a building)
   - Different parts of a classroom (e.g. near a heater, near the door, in an aquarium or pond, a mini-fridge)
   - Optional: Surfaces of different materials (e.g. metallic, cement, soil, wet soil) (Because this activity involves using glass parts, extra care must be taken when using the thermometer against hard surfaces)

5. Students use the data to construct appropriate data displays in the form of tables, column graphs or dot plots.

   Suggestions for how to do this with different year-level groupings is given in the following section.

6. Discuss the results as a class.

   What is the average temperature? What is the most frequently occurring temperature? What is the difference between the highest and lowest temperature?

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

For younger students, this activity is best conducted as a teacher-led activity. Students suggest items to take readings of, and the teacher helps student-volunteers to take the temperatures. Students identify items and places where they think temperatures are high or low (e.g. in a sunny/shady area of the classroom, an aquarium, in a water bottle, a teacher's warm cup of tea, near the heater/air conditioning, and in an insulated lunchbox). Readings can be taken to the nearest whole number.

The teacher presents the data in a table and represents it on a number line. Based on these numbers, students should be able to identify which is hotter and cooler. And for students who can, they can calculate how much hotter or cooler an object is compared to another.

Years 3/4

This mathematics-based activity complements the topic of heat energy that students learn in science. The teacher poses one or two questions for students to investigate in small groups of three or four.

These investigations could be related to conductors and insulators, or the ability of materials to absorb heat (e.g. Do conductors such as wooden chairs, and insulators like metal spoons have the same temperature? Where are the 'hottest' and 'coolest' places on the outdoor playground?).

Students collect their data and construct suitable data displays in the form of tables, column graphs, or picture graphs. Are they able to explain patterns in the data they have collected?

Years 5/6

This activity could be done in small groups of three or four, where students pose and refine questions to investigate related to sustainable living and energy efficiency (e.g. Do natural materials like rocks and soil keep the ground cooler than man-made materials like cemented areas and paved roads? Where are the coolest and hottest parts of the school building? How does the classroom temperature vary throughout a day?).

Students gather the data and present them in tables, column graphs or dot plots. Are students able to identify areas of unnecessary heat loss or heat gain and make suggestions to make the building more energy-efficient?

DISCUSSION SECTION AND KEY THEMES

KEY THEMES

Heat is an energy

Heat is a form of energy, and like all other types of energy, it is defined as the ability to do work (to move). In simple terms, when an object possesses heat energy, it can MOVE.

Even when an object, such as a stationary bicycle under the hot sun, doesn't appear to be moving, the atoms and molecules that make up the bicycle are. Depending on what state of matter the components of the bicycle are, atoms and molecules could be vibrating in fixed positions, or moving randomly around one another.

All objects possess some amount of energy and the only ones that almost do not are the few atoms and molecules that are kept in the Bose-Einstein condensate state under laboratory conditions.

Heat can be measured

Measuring temperature using a thermometer is one way of indicating how much heat energy is in a material. However, heat energy and temperature are not the same thing. The heat an object contains is the amount of its thermal energy and is measured in Joules (J). Temperature, on the other hand, represents the average kinetic energy of the atoms and molecules in an object, and is measured in degrees Celsius (˚C).

A swimming pool at 36˚C has a lower temperature than a cup of hot coffee at 85˚C, but because the swimming pool contains more water, it stores more heat energy than the cup of coffee.

Thermometers

There are several types of thermometers found in the home for different purposes. Bimetallic thermometers are used in appliances, such as ovens and air conditioners; digital probes and sugar thermometers are used in cooking; and digital, ear, infrared and strip-type are commonly used for taking human body temperatures.

Liquid-in-glass thermometers

Typical classroom thermometers are usually liquid-in-glass thermometers. They contain liquids within a narrow capillary. Liquid mercury was the preferred liquid for a long time because of how it expands uniformly with heat, but due to safety concerns, it has been replaced by alcohol-mixtures instead. Other parts of a liquid-in-glass thermometer include a bulb, the stem, a scale, a contraction chamber, and an expansion chamber.

All parts of the thermometer are carefully engineered equipment to provide accurate readings. As temperature increases, the liquid in the bulb expands in volume and rises up the capillary.

When the temperature decreases, the liquid decreases in volume. As a result, the liquid either moves up or down the thermometer with changing temperatures. There is a scale on the outside of the stem where the numbers have been adjusted to reflect the temperatures.

QUESTIONS AND ANSWERS

Why do things feel warmer in the sunlight?

The Sun sends out (radiates) light energy which reaches Earth. When the light energy reaches surfaces, such as roads, trees, buildings, playgrounds, and water, it gets absorbed and transformed into heat energy. That is why things in sunny places feel warmer than those in the shade.

Can something have no heat at all?

There is a theoretical point at which this could happen. It is called absolute zero - the lowest possible temperature where atoms and molecules have no energy. This temperature is expressed as 0K on the Kelvin scale, which is equivalent to -273.15˚C. Scientists have tried but have concluded that absolute zero is a mathematically impossible situation in real-life.

The current world record for the coldest temperatures achieved is 38 trillionths of a degree above absolute zero, by researchers at the University of Bremen, Germany in August 2021. Scientists go through all this trouble so that they can study the strange behaviour of matter. They have discovered that, at such low temperatures, atoms can exist in two places at once, and light becomes pourable like liquid!

[Absolute zero is absolutely impossible! (csiro.au)]

Where is the coldest place in the universe?

The Boomerang Nebula, a cloud of gas and dust in outer space, has an average temperature of -272.15˚C, which is just one degree Celsius above absolute zero!

The nebula can be found in the direction of the Centaurus constellation, about 5,000 light years away.

What is the maximum temperature for living things?

The maximum temperature varies for different types of living things but generally, at temperatures above 60˚C, only simple organisms like bacteria can survive. In fact, some heat-loving bacteria (thermophiles) that live deep below the ocean floor thrive in temperatures over 120˚C!

The upper temperature limit for 'complex organisms' like plants and animals, on the other hand, is less than 50˚C.

For humans, when outdoor temperatures reach 40˚C and higher, there is a real danger of heat stress and heatstroke.

Life at High Temperatures (wisc.edu)

How hot is the Sun?

According to NASA, the hottest part of the Sun is its core, where temperatures go beyond 15,000,000˚C. The surface of the Sun, also known as the photosphere, is only about 5,000˚C by comparison.

Interestingly, the temperature gets hotter further away from the surface of the Sun, towards the atmosphere. Temperatures climb up to 2,000,000˚C in the Sun's outer atmosphere.

Who is Kelvin and why is he a temperature?

The two scales used to describe temperatures for everyday living are the Fahrenheit (˚F), which is used in the United States, and the Celsius scale (˚C) which is used everywhere else in the world. The Kelvin scale

(K), on the other hand, is used widely in the scientific community.

It was defined by physicist Lord Kelvin in 1848, and it is useful for scientific calculations because there are no negative numbers and changes in the temperature directly corresponds to the changes to the amount of kinetic energy and volume of an object. We cannot do this with the Fahrenheit and Celsius scales.

How does the Bureau of Meteorology (BOM) make weather forecasts?

The Bureau makes seven-day forecasts (predictions) by using data from weather stations and weather satellites. Data that is collected, such as pressure, temperature, and rainfall, are put into computer weather models which churn out weather forecasts to help Australians plan their week.

In fact, the supercomputers at the BOM are so powerful, they can handle more than 1,600 trillion calculations per second!

Explainer: how meteorologists forecast the weather - Social Media Blog - Bureau of Meteorology (bom.gov.au)

Which planet has temperatures closest to that of Earth's?

According to NASA, the daytime temperatures on Mars can go as high as 0˚C - like winter temperatures on Earth. However, since Mars' thin atmosphere cannot hold onto the heat from the Sun, night-time temperatures are typically as low as -128˚C! Brrrrrr!!!!

Solar System Temperatures | NASA Solar System Exploration

Why do deserts get so hot in the daytime, and so cold at night?

It has to do with having lots of sand, and very little water in the air (low humidity). Unlike other environments, such as forests and mountainous regions, desert sand doesn't absorb heat well. Instead, it reflects the heat back into the air, making the desert air especially hot in the daytime.

And because there is not much humidity to trap the heat in the air, the heat is rapidly lost, causing the temperatures to drop drastically at night.

Based on satellite calculations, the Lut Desert in Iran recorded the highest temperature of 70.7˚C in 2005! In winter, night-time temperatures can go as low as -4˚C.

Who invented the thermometer?

The first thermometers were called thermoscopes and, while many people had invented different versions of it, the credit goes to Italian inventor, Santorio Santorio, because he had put a scale with numbers on it in 1612.

The thermoscope eventually gave way to the thermometer.

A German, Gabriel Fahrenheit, invented the first mercury thermometer in 1714 and devised the Fahrenheit scale, which is still in use today.

OUTSIDE OR SUPPLEMENTARY READING

Thermometers

- How Does a Thermometer Measure Air Temperature? (thoughtco.com)
- Who invented the thermometer? | Brannan

Heat

- Heat - A simple introduction to the science of heat energy (explainthatstuff.com)

TOPIC WORDS

- Temperature
- Heat
- Cold
- Hot
- Measure
- Degrees
- Celsius
- Fahrenheit
- Scale

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