At Right Angles
A Resource for School Mathematics

AS HOT AS MATH?
AS COOL AS MATH?

PADMAPRIYA SHIRALI

Azim Premji University
A publication of Azim Premji University

Keywords: Temperature, experimentation, observation, documentation, analysis, lifestyle change

The content of the PullOut section has, so far, largely been topic based and focussed on mathematical activities and pedagogy. This particular PullOut is an attempt at integrating mathematics with science concepts in order to develop responsible ways of living.

The topic covered- Temperature -is appropriate for upper primary, class 6. The objectives are to understand the concept of temperature and the factors that affect it, discuss and experiment with ways of measurement of temperature and to notice its relationship to our daily living.

All over India we are experiencing hotter summers and unusual winters. Our day-to-day conversations include talking about the weather: the heat, rainfall, lack of water. Predictions about the weather and rain are eagerly being watched, discussed and anticipated.

The study of weather and temperature is topical for all of us during the current period. The topic provides scope for measurement and data collection and allows easy linkage with other subject areas: Geography (physical features that play a role); Physics (how heat is absorbed, radiated and conducted), data related to temperature rise, etc.

The study of temperature should incorporate observations, data collection, data representation and interpretation. It is worthwhile to study past data, to analyse records about factors that play a role and look for patterns.

Apart from conducting experiments to understand the concept of temperature and learning to estimate and measure temperature, it is important that the students begin to ask questions about everyday things that they take for granted or tend to overlook. Each question has the potential to lead to further questions that help in understanding the topic at a deeper level.

In this PullOut, I share varied experiments that can be conducted to develop an observation-based understanding of the concept, and raise questions to explore the topic further.

Expectation of prior knowledge

- Notion of temperature: Students should know about body temperature and how it is measured. They would have also experienced hot days and cold days and the temperature difference between summer and winter seasons.
- Ability to compare two/three objects of different temperatures and order them. Use proper vocabulary: boiling, very hot, hot, warm, cool, cold, very cold, freezing.
- Idea of average as a measure.
- Idea of a line graph and basic skill of reading a vertical/horizontal axis

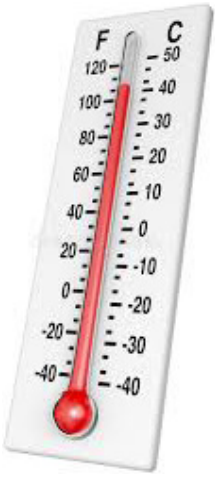
Concept: Temperature is the measure of the amount of heat present in a body, air, liquid or any substance. Explain to the students that temperature is the degree of hotness or coldness of an object. Children often confuse heat and temperature, regarding them as the same. The measurement of temperature is done in the Celsius system (named after a scientist). The short form used is °C.

Usage: Show students the usage of a thermometer. It is better to use an analogue thermometer rather than a digital thermometer for measurement activities. The bulb should only touch what is being measured. The thermometer should be held in place for at least one minute until the red material stops moving.

Caution: Clinical thermometers should not be used for measurement activities.

INVESTIGATION 1:

Objective: To learn to read a thermometer scale



Introduce the topic of how the summer affects all of us and let students express what they feel about it. It is bound to bring up numerous complaints and difficulties faced by them. On their own, students may wonder about aspects of weather and ask their own questions. If they do not, raise questions to help students come up with ideas for experiments.

What time of day is it the hottest? When does the temperature begin to rise? Does it rise evenly? How long does it stay that way? When does it begin to reduce? Is there any pattern from day to day?

Discuss these questions before they start doing any measurements. Let students record their ideas and assumptions about these questions.

Give students an analogue thermometer which records the air temperature. Place the thermometer vertically up. (Tape it to a sturdy box, if necessary).

Investigate what happens to the red liquid in the bulb of the glass tube over a period of time.

The students can form groups and each group can measure the temperature in turn.

Show students how to read the temperature on a thermometer correctly and the usage of the scale. Let the students decide at what intervals they will take the measurements and record them. Ideally, they should do it every 30 minutes.

Time	Estimated temperature	Actual temperature
9.00		
9.30		
10.00		
10.30		
11.00		
11.30		
12.00		

After each measurement they can write down their estimate for the next recording. By afternoon, they may predict a reduction in the temperature.

In the following math class, students can discuss the recorded data. Does the data match their earlier assumptions? Has the rise started earlier/later than expected? Is the maximum temperature recorded at noon time? Or later than noon? Do they see any pattern in the way the increase/decrease has happened?

What other data can we draw from this information? Will the difference of maximum and minimum temperature be of any use to us? To whom will it be useful? If someone plans to visit this place, how will they find this data useful? If we had to describe the temperature with an approximate figure, what figure would we use? Do students have an intuitive sense of average?

INVESTIGATION 2:

Objective: To understand the functioning of a thermometer

Mr. Mehta works in an aquaculture farm where they breed certain types of fish in artificial ponds. He needs to check the temperature of the water as algae blooms and also grows more quickly in warmer water. Growth of algae can cause a reduction in the amount of oxygen available in the water, causing problems for fish and wildlife.

What is the temperature of tap water (note: tap water can be quite hot in summer!) Fill a beaker with tap water and place the thermometer in it. What reading does it show? Perhaps around 25°C? Try with slightly lukewarm water.

Look at the thermometer scale closely. On the Celsius side, why do the markings go from 50 down to 0 and further to –40 degrees. What does that mean?

What happens to the red liquid? It rises and moves up the tube. Explain the functioning of a thermometer in simple terms. When the air around becomes warmer, the liquid expands, and it moves up the tube.

Try with cold water. What happens now?

Watch how the students conduct the investigation. Did they notice that the level of the liquid fell? Can they explain why? Were the explanations given with care and thought? Did the students discuss with seriousness, and did they listen to each other attentively?

Explain that when the air becomes cooler, the liquid cools and contracts.

Fact: Hot water from natural hot springs can have a temperature above 50°C and in some cases above the boiling point of water (100°C).

Let students reflect: What are the various situations where we use hot water at home? Do industries use hot water too?

INVESTIGATION 3:

Objective: To learn that water boils at 100°C and freezes at 0°C.

At what temperature does water boil? Freeze?

To check the temperature at boiling point, which needs to be done with a lot of care, use a laboratory thermometer. Students can use a kettle to boil water, pour out some into a beaker and check the temperature.

Students can be given ice cubes in a beaker. The temperature of the cubes will be close to 0°C.

INVESTIGATION 4:

Objective: To learn that answers can vary and are dependent on various factors.

How long does it take for a water bottle to freeze?

Let the students discuss the various factors that affect the situation before they estimate an answer.

Do they see that the starting temperature of the water will alter the time?

How about the volume of the water? How about the container which holds the water? What about the temperature of the freezer?

What are the various things that they can do to speed up the freezing?

Another question to investigate is: What is the temperature of water from a water cooler/fridge (cooled for a long time)? What is the temperature of water from a *matka*?

The clay pot (*matka*) has been a staple in Indian households. Some people think that it is better to drink water cooled in an earthen pot rather than in a refrigerator. Find out from a doctor if it is so. What are the reasons given by the doctor?

INVESTIGATION 5:

Objective: To observe the variation in temperature as the location varies

Is the temperature in a shady region (under a tree) less? By how much? What pattern does the temperature in a shady region follow? Is it always less than a sunny spot by the same number of degrees?

Does the temperature in the classroom follow a similar pattern? By how many degrees is it less than the outside temperature? Is it always less than a sunny spot by the same number of degrees?

Discuss: Which areas in the classroom are hot? Which areas are cooler? Why? Is there a difference between the temperature at the ground level and ceiling level? What could be the reason? What happens in summer when you put on a ceiling fan?

Let the students do the necessary measurements by selecting suitable places and recording the data. Students should display their recordings in the form of a line graph to contrast the different settings. What inferences do the students make? Are they able to give reasons for their inferences using the given data? How far did their predictions come true?

Location	Sunny spot temperature	Shady spot temperature	Inside classroom temperature
9 AM			
11 PM			
1 PM			
3 PM			

INVESTIGATION 6:

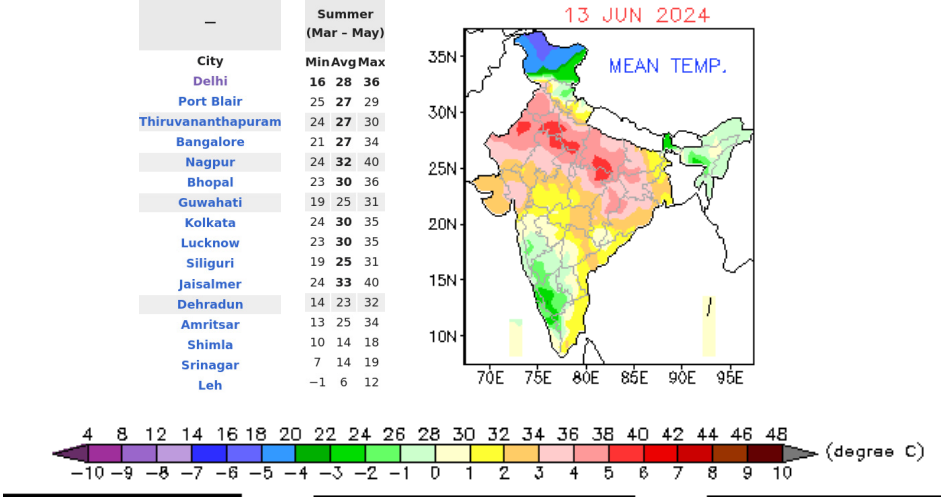
Objective: To explore the topic further by moving from local temperatures to temperatures across the country

Do other places, say, capital cities of states (or other districts in the state) in India experience similar temperatures at this time? What cities are those? Which cities have higher temperatures? Which cities have lower temperatures? What could be the reason for the difference?

Use a visual or data table containing information about the temperatures of different cities.

Average temperatures in various Indian cities (°C) (https://en.wikipedia.org/wiki/Climate_of_India)

–	Summer (Mar - May)		
City	Min	Avg	Max
Delhi	**16**	**28**	**36**
Port Blair	25	**27**	29
Thiruvananthapuram	24	**27**	30
Bangalore	21	**27**	34
Nagpur	24	**32**	40
Bhopal	23	**30**	36
Guwahati	19	25	31
Kolkata	24	**30**	35
Lucknow	23	**30**	35
Siliguri	19	**25**	31
Jaisalmer	24	**33**	40
Dehradun	14	23	32
Amritsar	13	25	34
Shimla	10	14	18
Srinagar	7	14	19
Leh	−1	6	12



https://mausam.imd.gov.in/ClimateInformation/imdweb/DAY_WEEK/t-0.gif

Students should mark these places and record the information as an exercise on a map and study it.

Let students notice the various aspects of this data. Encourage them to formulate questions. Raise some guiding questions. Are there similarities in the coastal areas? What physical features of India can be seen in many of the regions marked green? Is there a presence of hills? Forests in these regions? In which places is the difference between the minimum and the maximum the highest? Which part of India are they located in? What physical features can be the reason for Jaisalmer's temperatures?

Facts: The highest temperature ever recorded in India occurred in May 2016 in Jodhpur District, Rajasthan at 51.0°C. The lowest recorded temperature in India was –45.0°C in Ladakh in January 1995.

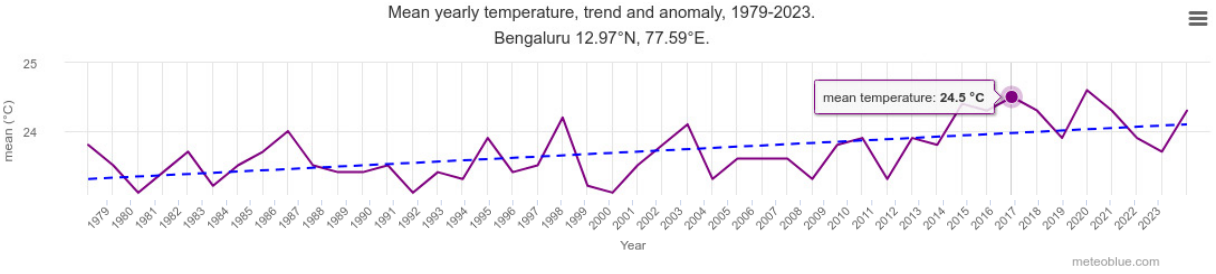
Mark these places on the map. Is there anything common to both these places?

INVESTIGATION 7:

Objective: To notice and analyse the changes that happen over time

Ask the students about stories that they have heard from their elders about their experience of summers. Most students would have heard their parents, grandparents talk about their younger days when they could manage without the need for air conditioners, coolers, refrigerators, etc. They would have heard stories of being able to sleep on a terrace or on verandahs under the open skies.

Pose the question: How have the temperature measures changed over the years in our region?



https://www.meteoblue.com/en/climate-change/bengaluru_india_1277333

Use data of a nearby city and let students make their observations about their findings. While this particular graph also shows the trend line, the average (mean) temperature graph is adequate to notice how the yearly temperatures are rising.

In which years has the purple line crossed 24°C? Is the rise happening frequently in the past few years? What could be the cause of this rise? Does it have to do with the rise in population? How would that affect the temperature?

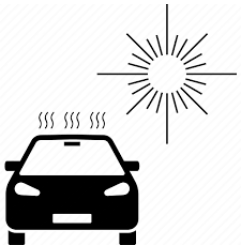
Does it have to do with industrial pollution? Does it have to do with excessive constructions?

Does it have to do with the usage of cement, glass in our constructions?

Note: Research and find out how overpopulation, industrial pollution, concrete constructions affect the temperature.

INVESTIGATION 8:

Objective: To understand the effect of heat on metal.



Most of us have experienced the discomfort of getting into a car, bus or a railway engine that has been parked in the sun.

Pose the question: How do various materials respond to temperature rise? How hot does it get in a car?

Students can use a tin box, check the temperature inside the box before placing it under the sun. Let them measure the temperature every five minutes and record the results.

Discuss how quickly the temperature inside the box has risen. Talk about the need to stay hydrated while traveling in or waiting for buses or trains, particularly during the summer.

Facts: After just 20 minutes on an average 26-degree day, the inside of a parked car can hit 42°C. After 40 minutes, the temperature can touch 47°C.

INVESTIGATION 9:

Objective: To understand the significance of water temperature for aquatic life.

Discuss how water temperature affects aquatic life. Certain types of fishes and aquatic life thrive well in the sea and some thrive well in lakes. What is the difference? Is the ocean water warmer than the river water?

Find out: About the temperature of water that is needed by fishes and whales, etc.

Fact: The Indian Ocean basin is the warmest ocean basin on the planet and the temperature can reach up to 28°C.

INVESTIGATION 10:

Objective: To observe the temperature at which beverages are consumed.

We all enjoy beverages and hot chocolate or hot coffee might be an interesting drink to study. At what temperature can we have these drinks without burning our mouths? At what temperature do they taste good? How long do I need to wait for boiling milk to cool down before I can have it with cocoa?

Fact: Incidentally, discuss whether the boiling point of milk is the same as the boiling point of water. Boiling point of milk is very close (100.5°C)

Let students measure the temperature of boiling water (milk is difficult in a classroom, but a kettle of water can be easily heated in a classroom) to test whether it is close to hundred degrees. Let them check the temperature every 5 minutes to find out how the temperature decreases. Ask the students to record

the results on a line graph showing time in seconds (horizontal axis) and the temperature readings in °C (vertical axis). What do they notice about the graph?

Find out: At what temperature are biscuits/cakes baked?

Fun activity: Let students name a few places that they consider as the warmest spot in the school. In each of these places they can place an ice cube and measure the time that it takes to melt.

INVESTIGATION 11:

Objective: To understand how quantity affects heat loss.

Does a large amount of water lose heat faster than a small amount of water?

Pour hot water into a large container and a small container. Check the temperature of both the containers every 5 minutes. Plot a graph. How do the two graphs differ?

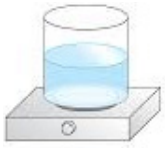
INVESTIGATION 12:

Objective: To understand heat transfer.

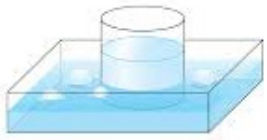
Raise the question of how hot things can be cooled quickly. Most students would have noticed their parents placing boiled potatoes in cool water or a hot glass of milk in a vessel of cold water to bring down the temperature.

Different questions can be raised for experimentation purposes. How long does it take for a cup of boiling hot water to decrease by 20°C? By how much does the temperature reduce if you keep a hot cup in ice cold water for 5 minutes?

Place warm water in a cup (A) and check the temperature. Place the cup with the thermometer in a basin containing cold water and ice cubes (B).



A



B

Let the students note the change in the temperature of the warm water.

Ask the students what they notice about the temperature of the water? Is it getting warmer or colder, or staying the same?

What is happening to the cold water? Is it getting warmer?

Point out how heat is being transferred from a warmer object to a colder object.

If the heat of the water has to be retained in a tumbler what are the various things that they can do?

INVESTIGATION 13:

Objective: To understand the effect of colour on heat absorption.

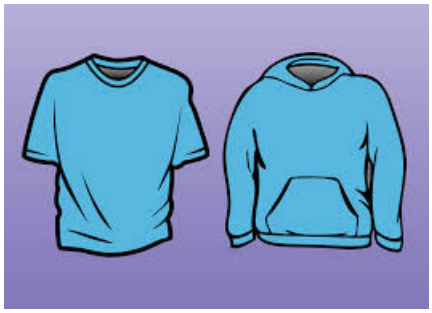
What effect do various colours have on heat absorption?

Students can fill 4 jars of the same size with equal amounts of water, cover them with different coloured papers (black, pink, blue and white) and place the jars in a sunny spot. They can make a prediction about which tumbler will hold the warmest water and which will hold the coldest. Did their prediction come true?

Discuss a related observation about why people wear light coloured clothing in the summer (corroborated by the earlier experiment) and dark clothing in winter. Explain that darker colours absorb more sunlight than lighter colours. Hence, darker colours get warmer more quickly in the sunlight than lighter colours.

INVESTIGATION 14:

Objective: To understand the function of clothing in retaining temperature.



Discuss what is best to wear on a cold day. A sweater or a T-shirt? Students will readily agree that they would wear a sweater.

Raise the question 'Is the sweater or T-shirt warm in temperature? If the sweater is not warm, how does it help to keep you warm?'

Give the students cues about body heat, the effect of cold air, how the sweater provides a protective layer.

Human beings use sweaters or jackets to retain their body warmth. What do animals do? Have they evolved natural coats and jackets? Students would have noticed how some animals are very hairy, some have fluffed up feathers, some are covered with wool. Discuss how thick layers of fat protect some animals from cold weather.

INVESTIGATION 15:

Objective: To notice the heating and cooling implements used at home.

What are the various ways of preserving heat in solids and liquids? Let students bring up examples of appliances that they use at home. (Geysers, Hot Water bottles, Thermos flasks, etc.)

Encourage the students to formulate questions about these appliances. For example, What is the maximum temperature of a geyser? What gradations of temperature are given on an iron? etc.

Students can find out how people preserved fruits and vegetables in the past. What techniques were used in constructions to keep a house warm/cool?

Fact: Liquid mercury freezes at -39°C temperature and boils at 357°C temperature.

INVESTIGATION 16:

Objective: To become aware of places with extreme temperatures.

Discuss how people cope with summer heat in different ways. Some people like to travel and where do they go?

Most people like to visit cooler places during summer. People in South India may like to go to Ooty or Coonoor. If they are in the northern part of India, they may go to Uttaranchal or Himachal. If they are closer to the North-East, they may visit Sikkim or Darjeeling. The temperature in Ooty may be below 25°C, in Himachal, it may range between 20°C and 25°C, Sikkim may be around 22°C. If people go high up to the foothills of the Himalayas or to Gangotri (where the Ganga river starts from), the temperature may be -1°C. They will need warm clothing! Definitely, they will experience much relief from the scorching weather of 35°C to 45°C in most places of India at that time.

Hardly a place to visit! But who would want to visit these places?

- Eastern Antarctic Plateau, Antarctica (-94°C)
- Alaska, United States of America (-73°C)
- Greenland (-69.6°C)
- Siberia, Russia (-67.7°C) (Schools shut down only if it's colder than -55°C!)
- Yukon Territory, Canada (-62.8°C)
- Alaska, United States of America (-62.1°C)

How would a line graph for this data look, if it is arranged in descending order of temperatures? Will it be going down from left to right or rising from left to right?

If the temperatures rise by 15°C in each of these places, how would the line graph change in appearance?

If the temperatures fall by 2°C in each of these places, how would the line graph change?

Here is a list of the top ten hottest places in India. What is the difference between their temperatures? Do you live in any of them? What measures do people take to protect themselves against heat?

Find out: Names and temperatures of the five hottest places in the world.

Top Ten Hottest Places in India

Sno.	Place	Maximum Temperature
1.	Delhi	44°C
2.	Churu	50°C
3.	Sri Ganganagar	50°C
4.	Bilaspur	49°C
5.	Nagpur	48°C
6.	Banda	48°C
7.	Vijaywada	45°C
8.	Jhansi	47°C
9.	Titlagarh	45.5°C
10.	Phalodi	51°C

Project: Be a meteorologist!

Objective: To help students learn to build tables and records over a period of time in a systematic manner for finding patterns and doing analysis.

Discuss what a meteorologist does, how they gather information and look for patterns. Students should be made into groups to record and describe daily temperatures at specific times. They can also record other weather markers. Based on the patterns they observe, they can make predictions for the succeeding day or week. They can contrast their prediction with the standard weather reports. How close were their predictions to the actual?

Ask students to start recording/ describing everyday weather in a chart. Use the measured temperature and words such as sunny, windy, cloudy.

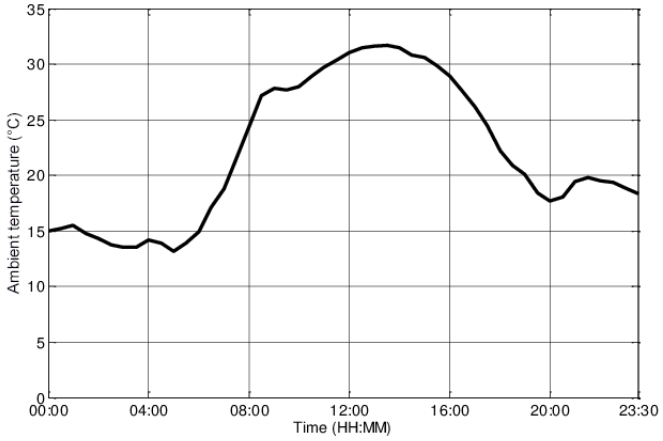
Compare everyday weather forecasts given in the newspaper/weather website for a week with the actuals. (make a graph of both to contrast the two figures.)

Discuss: What are the situations where we need exact temperature measurements?

INVESTIGATION 17:

Objective: To interpret temperature graphs

The graph shows what happened to the temperature during day and night. At what time did it begin to rise? At what time did it begin to fall?

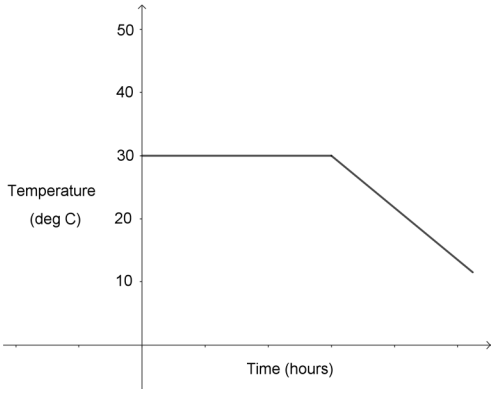


Which of the following graphs shows temperature being constant?

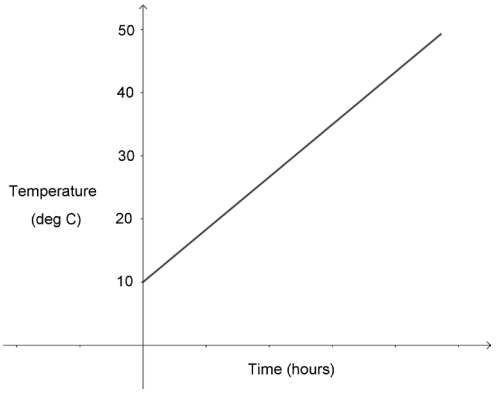
Which of the following graphs shows temperature being constant and then getting colder?

Which of the following graphs shows the temperature getting warmer?

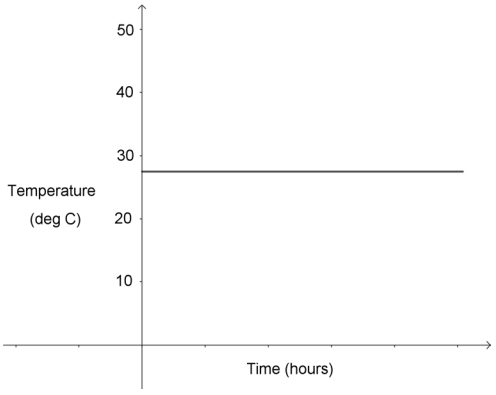
Which of the following graphs shows temperature being constant and then getting warmer?



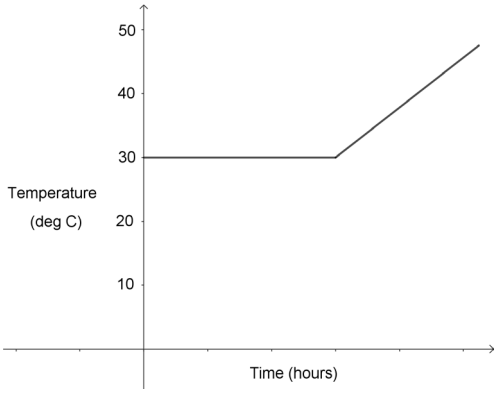
Graph A



Graph B

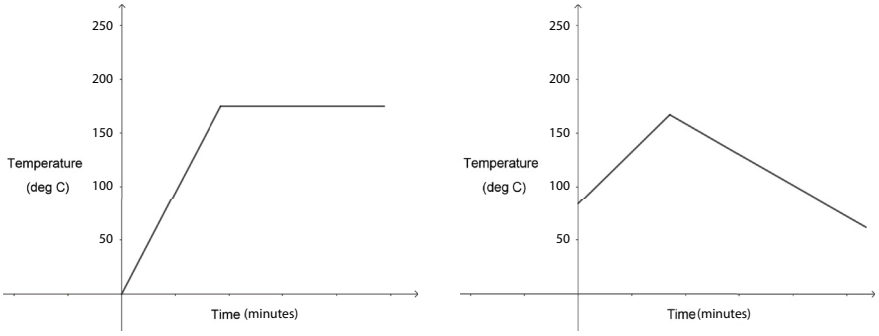


Graph C



Graph D

Ruhi preheats her oven to make a cake. Once the oven is warm, she puts the tray in the oven for baking. Which of these graphs shows her oven temperature during this process?



Discussion: Objective: To understand personal responsibility. 'What can we do? How can I help?'

Many factors contribute to the rise in overall temperatures in the world. Teachers should discuss the topic of global warming at age appropriate level with the students.

It may not be possible to do much about them at a young age. But one can begin to do small but important things so that we do not contribute to the problem.

Turn off lights, TVs, computers when you are no longer using them!

Unplug any electronic device that you can turn on with a remote (TV, DVD player, laptop etc.). These devices use power even when they are "off."

Reduce the usage of AC. When it is hot, use fans, which use less energy. When it is cold, wear warm clothing to conserve energy.

Walk, or ride your bike instead of taking a car everywhere.

You can help by growing your own vegetables and fruits.

You can help by planting a tree.

Use reusable grocery bags.

Recycle everything you can.

Use less paper whenever possible.

Drink filtered water instead of bottled water. Carry your drinking water in a reusable bottle. Plastic water bottles are an environmental disaster!

Buy the product that uses less packaging material. Even if you recycle packaging materials, it takes energy to create them in the first place and energy to remake them into something else.

A study of topics like Temperature should encourage experimentation, documentation of results, and analysis of data and should lead to understanding that serves as a propellor for changes in one's lifestyle.

TEMPERATURE QUILT

A temperature quilt is usually a year-long project that can be undertaken by students of a class, especially if they are doing a study of temperature along the lines suggested in this PullOut.

Each day, you make a block depicting the high and low temperatures of that day. The choice of colours is entirely up to you, so is the block pattern. The blocks can be sewn by hand or with a sewing machine. The range of temperature is decided based on the place in which the data is being documented. The high and low should be recorded at the same time each day.

Figure 1

Quilter Chitra Lakshminarayan who is based in Chennai, chose the colours shown in the chart in Figure 1.

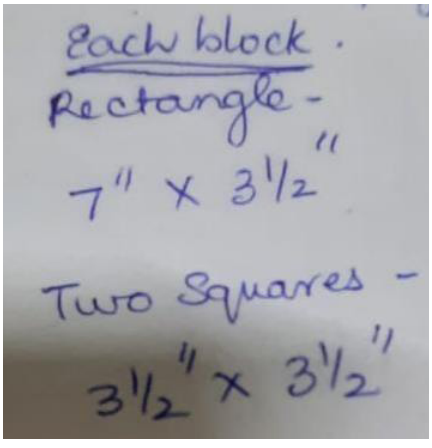


Figure 2. Each day's block was a 3.5 inch by 7 inch rectangle, composed of two 3.5 inch by 3.5 inch squares.

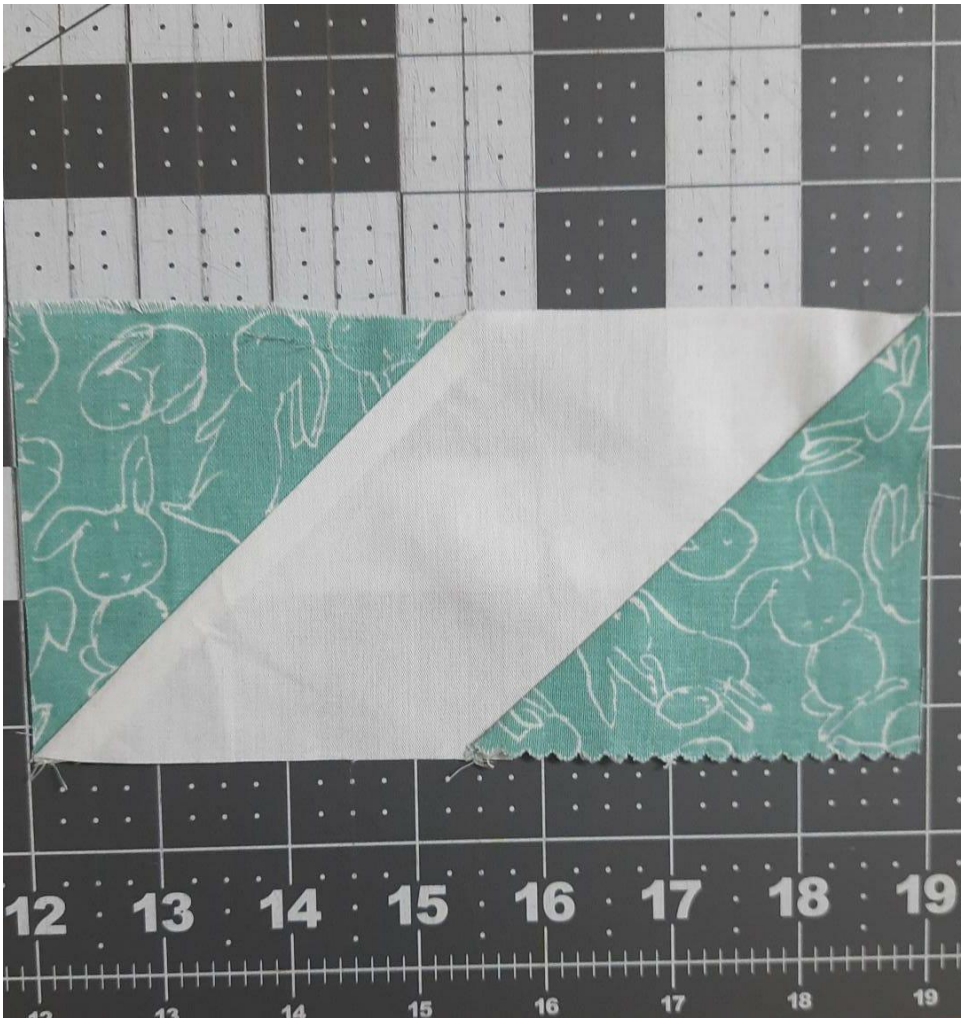


Figure 2

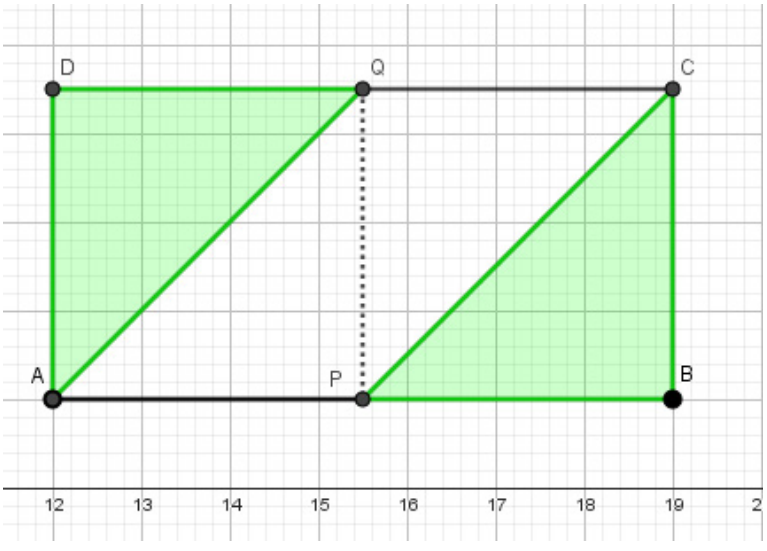
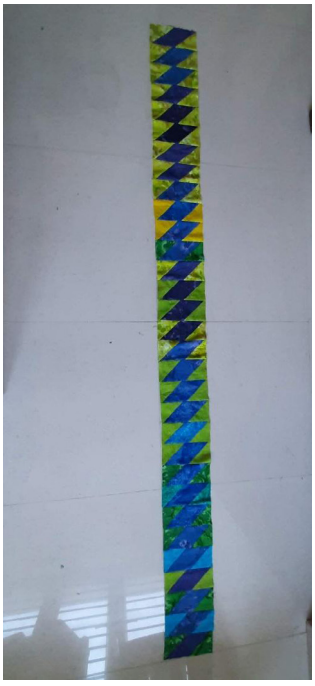


Figure 3

The parallelogram AQCP in the centre shows the low of the day and the triangles ADQ & PCB at the corners show the high of the day. How many congruent triangles do you see? The quilter begins by cutting 3.5 inch by 3.5 inch squares in each of the two colours (green and white) and then making half-square triangles which are then sewn together to make squares with contrasting triangles. The squares are then joined to make a 3.5 inch by 7 inch rectangle!

Finally, the rectangles for each month are sewn together to make a strip and then the strips are combined at the end of the year to make the beautiful quilt shown in Figure 4.



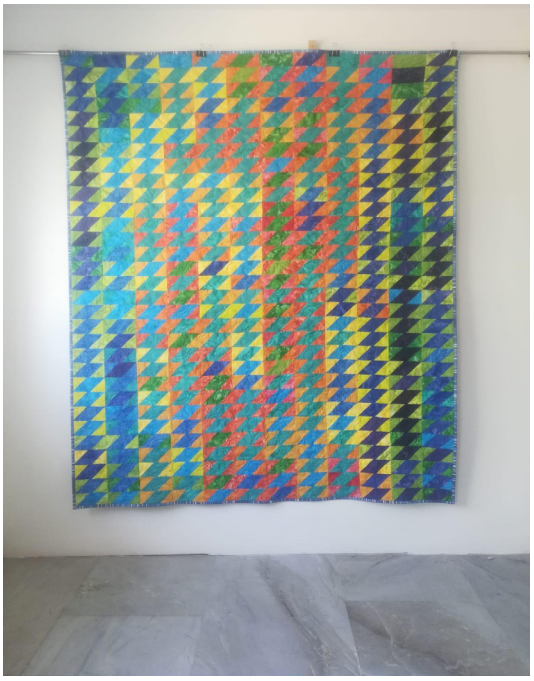


Figure 4

Figure 5a

Figure 5b

Figure 5 shows two temperature quilts made by Geetha Srinivasan, she documented temperatures in Chennai (Figure 5a) and in Sheffield, UK (Figure 5b). Notice the difference in the choice of size of blocks, geometry patterns in the blocks as well as colours.

Temperature quilts are an innovative way to document data, giving scope for creativity and innovation. Quilters are historians too!

Note from Editor: All the quilts shown were quilted at The Square Inch, Chennai.

PADMAPRIYA SHIRALI

PADMAPRIYA SHIRALI is part of the Community Math Centre based in Valley School (Bangalore) and Rishi Valley (AP), where she has worked since 1983, teaching a variety of subjects – mathematics, computer applications, geography, economics, environmental studies and Telugu. In the 1990s, she worked closely with the late Shri P K Srinivasan. She was part of the team that created the multigrade elementary learning programme of the Rishi Valley Rural Centre, known as 'School in a Box.' She is currently part of the NCERT textbook development group. Padmapriya may be contacted at padmapriya.shirali@gmail.com