Lesson 4: What influences temperature?

Goals

- Contrast (orally) the benefits of modelling data using functions to identify input/output pairs and using statistics to analyse bivariate data.

Lesson Narrative

This optional sequence of three lessons can be done any time after the probability and statistics in the course. Students develop and use a mathematical model to predict temperature given the latitude of a location. The activities in this sequence of lessons provide students a chance to go more deeply and apply year 9 mathematics to a real-world context. Students get a chance to engage in many aspects of mathematical modelling. The activities in this lesson build on each other, and so should be done in order. It is not necessary to do all three lessons to get some benefit, although more connections are made the further one gets.

In the first lesson, students investigate whether there is a relationship or a pattern of association between the north-south location (in North America) of a place and the temperature. This is a vague question, and the first step is to clarify the variables that we will consider for a mathematical model.

- The first activity gives students a chance to think about different factors that influence outside temperature. Some are geographical (latitude, desert or sea climate, height above sea level), others are time of year, cloud cover, time of day, etc. As a segue into the second activity, we ask if it is possible to vary just one factor so that we can predict how the temperature will respond. In particular, if we vary latitude, can we predict what happens to the temperature?

- In the second activity, students investigate whether the concept of a function is a good tool to model this situation: Is temperature a function of latitude? There are several issues with this question. The biggest one is that for the same latitude, we will get different temperatures at any given time. If we really want a functional relationship, then we would have to make many restrictions. For example, we could fix time and longitude. Then for each latitude as input we can report a unique temperature as output. This brings up the question of how meaningful this model would be. We will look at a variety of possibilities and discuss pros and cons.

- In the third activity, students discuss if a more meaningful model might be to look at an association between latitude and temperature, much like what they encountered in an earlier unit on bivariate data. Data like this is easy to find, and we don't have to worry about repeating "input" values.

In the next two lessons, students construct a mathematical model, analyse the model, use it to make a prediction, and discuss limitations of the model.

Throughout these lessons, students make and discuss choices, assumptions, and approximations as part of their work. While some of the choices and decisions are made as a class or through the sequencing of the classroom activities, students get a chance to grapple with all of these steps in the modelling cycle.

If it is feasible, students could be making more of the decisions themselves. For example, groups could come up with different proposals of how to investigate the relationship between temperature and latitude, present, get feedback, finalise, and then continue with different data for their model (for example, different months, different locations, different continents, or overall average temperature). For the full modelling cycle, they could then revise their assumptions and come up with a revised model.

There are many extensions possible for these activities. Students could investigate if there is a similar association between latitude and temperature in other parts of the world. They could look at different measures of temperature like yearly average, yearly average high or low temperature, or average high or low temperature in a different month.

Addressing

- Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
- Use functions to model relationships between quantities.
- Investigate patterns of association in bivariate data.

Instructional Routines

- Co-Craft Questions
- Discussion Supports

Required Preparation

For the first activity, consider finding out the latitude and average high temperature in September for your city.

Student Learning Goals

Let's see if we can predict the weather.

4.1 Temperature Changes

Optional: 5 minutes

In this activity, students think about different factors that influence outside temperature. Some are geographical (latitude, desert or sea climate, height above sea level), others are time of year, cloud cover, time of day, etc. This is a chance to make connections with some science concepts.

It is not important that students come up with an exhaustive list. They should just get the idea that there are many factors so that they are open to the idea that we'll have to make some choices for our model and clearly define any variables we want to consider.

Instructional Routines

- Discussion Supports

Launch

Arrange students in groups of 3–4. Tell students that they are starting an investigation on how to predict the weather, in particular the temperature. Check that students understand the example given in the activity statement, that as the time of day changes, the temperature often changes in a predictable way. They will brainstorm other factors that also influence the temperature.

Speaking, Listening, Representing: Discussion Supports. To tap into students' prior knowledge and experiences with weather and temperature, display images of various weather conditions. Include images that suggest cool or hot temperatures, showing the sun, wind, rain, snow, etc., in different locations (i.e., beach, mountains, etc.). In small groups of 3–4 students, ask each student to volunteer at least once to orally describe the weather they see and show with their body movement how the temperature feels. As each image is displayed, have a new student in the group take a turn.

Design Principle(s): Support sense-making; Cultivate conversation

Student Task Statement

What factors or variables can influence the outside temperature?

- Make a list of different factors.
- Write a sentence for each factor describing how changing it could change the temperature.

Example: One factor is time of day. Often, after sunrise, the temperature increases, reaches a peak in the early afternoon, and then decreases.

Student Response

Answers vary. Sample response:

- Time of year: It is colder in the winter and warmer in the summer.
- Location: It is colder toward the poles and warmer toward the equator.
- Altitude: The higher a location, the colder it gets.
- Cloud cover: The more clouds there are, the colder it is.

- Ocean currents: The Gulf Stream brings cold or warm water to parts of the ocean and moderates temperatures that way.
- El Niño and La Niña: Moisture in the atmosphere influences temperature.
- Global climate change: Greenhouse gases increase average temperatures.
- Volcanic eruptions: Ash in the atmosphere can lower temperature.
- Wind direction: A wind from the North brings colder temperatures.

Activity Synthesis

Invite students to share some of the factors they have come up with. Note that many of them are geographical. Point out that making a model that takes into consideration all or even many of these factors is very complex (weather forecasting is really difficult!). In mathematical modelling, we often start by fixing or disregarding (or randomising) all but one of the factors. In the next activity, we want to pick just one—latitude—and investigate how just changing the latitude changes the temperature.

4.2 Is Temperature a Function of Latitude?

Optional: 15 minutes

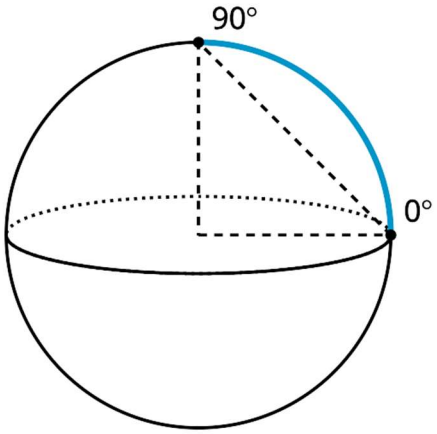
One mathematical concept students learned about in year 9 that relates to variables is the idea of a function. In this activity, students discuss if this is a helpful concept to investigate latitude and temperature. To be able to use functions, variables have to be very well defined, and in this case, many restrictions are necessary to have a functional relationship where each input has exactly one output.

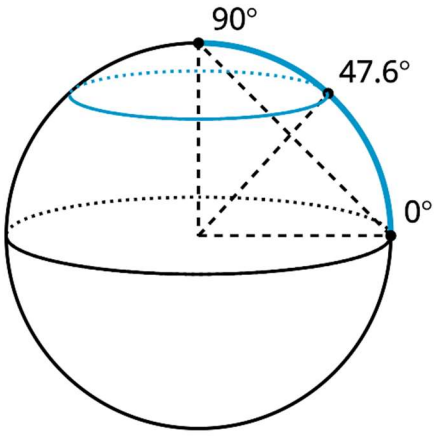
Launch

Keep students in the same groups. Ask students if they can explain exactly what latitude is. It was briefly discussed in the previous activity as one of the factors that can influence the temperature. Students should understand that latitude is a way to measure how far north or south of the equator a place is located. The unit of measurement is degrees north or degrees south.

Draw a sphere (representing Earth) for all to see and indicate the circle representing the equator. Draw a quarter circle starting somewhere on the equator and ending at the North Pole. A location on the equator is at 0 degrees north (or south), and the North Pole is at 90 degrees north. Note that the angle made by the arc is a 90-degree angle. Since North America (or the United Kingdom) lies entirely north of the equator, all latitudes there have units of degrees north.

In this activity, students look at locations at 47.6 degrees north. Ask students where on the highlighted quarter circle this latitude is located. Then draw in the corresponding longitude circle (parallel to the equator) to show that there are many locations that have the same latitude.





Representation: Internalise Comprehension. Provide appropriate reading accommodations and supports to ensure students access to written directions, word problems and other text-based content.
Supports accessibility for: Language; Conceptual processing

Student Task Statement

1. Andre and Lin are wondering if temperature is a function of latitude.

   Andre says, "I think it is, as long as we fix the time when we are measuring the temperature."

   Lin says, "But what if you have two places with the same latitude? Look at this weather map for Washington State. Seattle and Spokane have the same latitude but different temperatures right now."

   What do Andre and Lin mean?

2. Andre and Lin are discussing whether it is possible to define latitude and temperature in a way that makes sense to talk about temperature as a function of latitude. They are considering different options. What are some advantages and disadvantages of each option?

   Here are the options:

   a. Finding the temperature right now in cities with different latitudes.

   b. Finding the daily high temperature in cities that have different latitudes.

   c. Finding the average high temperature in a specific month, for example, September in cities that have different latitudes.

   d. Finding the average yearly temperature in cities that have different latitudes.

Student Response

1. Answers vary. Sample response: Temperature varies with time, so a time must be fixed to be able to talk about temperature as a function of location. The question "What is the temperature in Seattle?" has many different answers depending on the time the temperature is measured. Similarly, Seattle is not a single location, or more generally, "latitude" is not one single location. Even if a time is fixed, two locations that have the same latitude may have different temperatures.

2. Answers vary. Quite often cities at different latitudes have different temperatures.

   a. Answers vary. Sample response: The answers might not depict an overall pattern, as temperatures are influenced by local weather and time zones.

b. Answers vary. This answer draws upon similar issues as in part a, except for the time zone problem.

c. Answers vary. It is better to be able to draw conclusions about a general relationship. The issue with the "representative latitude" remains.

d. Answers vary. The answer is similar to that in c. This might be too much of an average. Some locations might have extreme highs and lows while others have closer highs and lows.

Activity Synthesis

Discuss why it is important to clearly define the variables.

- "Temperature" is a very general idea, and we have to decide what is the most appropriate measure of temperature for our investigation. There are many different choices, but some are more appropriate than others. We want to look at an average since this will be more representative than the temperature at one point in time. It also evens out some of the other factors that could influence temperature, such as random weather events.
- Latitude is a tricky variable since each latitude value represents infinitely many locations that all have different temperatures. We can fix one line of longitude, but then how representative will our results be?

There are two main takeaways of this activity:

1. It is important to clearly define the variables of the model.
2. The function concept might be too restrictive for us to use for our model.

Statistical methods are a better tool for investigating the relationship between latitude and temperature. We'll look at these in the next activity.

4.3 Is There an Association Between Latitude and Temperature?

Optional: 10 minutes

The idea of a function is very limiting when we wish to analyse the relationship between latitude and temperature. Looking at the situation from a statistics point of view is more helpful. In this case, the question becomes: Is there an association between latitude and temperature? This activity asks students to recall the setup necessary to answer this question. As an important step of mathematical modelling, they think about what data they need to collect, how they can collect it, and what methods will help them to analyse the data. This step is often done for students to save time, but it is non-trivial and even though in the next lesson the data will be provided, it is worthwhile for students to think about this step and to come up with a plan. If it is appropriate for a class, students can collect their own data rather than use the data provided.

Instructional Routines

- Co-Craft Questions

Launch

Tell students that as they saw in the previous activity, the function concept might be too restrictive in this case to create a useful model. Statistical methods are a better tool for investigating the relationship between latitude and temperature.

Brainstorm examples from earlier in the year on finding associations between variables, for example, year and price of a car, or weight of a car and fuel efficiency.

Representation: Internalise Comprehension. Activate or supply background knowledge around the term *association*. Provide students with examples of variables that have an association. Check for understanding by selecting a few students to share other possible situations that may have an association between the variables.
Supports accessibility for: Memory; Conceptual processing Conversing, Writing, Reading: Co-craft Questions. Display the following statement for all to see: "Death Valley holds the record for the hottest place on earth. In 1913, the temperature reached 134°F (56.7°C)! It can also get surprisingly cold, with temperatures below freezing." Give students 1–2 minutes to write down mathematical questions to ask about this statement. Invite students to compare their questions with a partner before selecting a few students to share with the class. Reinforce the idea that this is the same "location" with the same "latitude". Use this to reinforce the idea that other "factors" affect temperature besides latitude, and that a clear rule may not be easily generated and discussed by only looking at one "factor".

Design Principle(s): Cultivate conversation; Maximise meta-awareness

Student Task Statement

Lin and Andre decided that modelling temperature as a function of latitude doesn't really make sense. They realised that they can ask whether there is an *association* between latitude and temperature.

1. What information could they gather to determine whether temperature is related to latitude?

2. What should they do with that information to answer the question?

Student Response

Answers vary. Sample response:

1. Collect data that give the latitude and temperature at different locations in a geographical area (for example, North America). The temperature could be a yearly high temperature, an average temperature, or an average high temperature in a particular month. Latitude should have a wide enough range to show a pattern, such as examples from southern Florida to Alaska, including cities from different east-west locations.

2. Make a scatter plot to see if there is an association. If the association looks approximately linear, then find a line that best fits the data.

Activity Synthesis

To highlight some of the methods and ideas students will need, ask:

- "What are some ways we viewed associations between two variables in the past?" (We made scatterplots and fit trendlines to the data.)
- "What are some things we need to keep in mind when we collect our data?" (We should use a variety of north-south and east-west locations, or "enough" data to be able to draw conclusions.) (If not mentioned, tell students that three cities is definitely not enough, and 100 cities in the same vicinity is not necessary.)

In the next lesson, we will pick a particular measure of temperature—average high temperature in September—and analyse data to see if there is an association.