2040 - The Maths of Carbon

Name

Class

Teaching Sequence

Work through this resource material in the following sequence:

20 minutes – Part A: The Issue of Atmospheric Carbon
10 minutes – Part B: The Air That We Breathe
25 minutes – Part C: Tracking Earth's Atmospheric Carbon Record
10 minutes – Reflection

Part A: The Issue of Atmospheric Carbon

Step 1.

Show the following clip from the documentary 2040:

[2040 - Exploring the Themes](#) **Password: 2040_EDU**

While students are watching, invite them to complete the See, Hear, Wonder activity on the Student Worksheet.

SEE - HEAR - WONDER

SEE – What did you SEE in this clip?
HEAR – What did you HEAR in this clip?
WONDER – What does this clip make you WONDER about?

Step 2.

After viewing, lead the students in completing the following Think, Pair, Share activity on the Student Worksheet:

- **Column A -** There were many ideas presented in this clip, by the narrator, about the problem we face today regarding the Earth's atmosphere. What THREE ideas did you find most interesting?
- **Column B -** Share your thoughts in column A with a partner and note down anything new.
- **Column C -** What were some ideas shared in the class discussion that you hadn't considered before?

Think Pair Share
Think pair share is a collaborative learning strategy in which students work together to solve a problem or answer a question.
Think - students independently think about an issue or question and record their thoughts.
Pair - students work in pairs to discuss their ideas and record new thoughts.
Share - students share their thoughts with the whole group or with other pairs to reach consensus.

Take 3 to 6 minutes to conduct this session and summarise the class's thoughts about the video on the board.

Step 3.

This **interactive graph** from **The 2° Institute** shows an increase in anomalies of the global average temperature record since about 1900 and the overall increase in fluctuations in temperatures away from the long term global average since the 1960s. Show this graph to students and briefly discussed.

For a detailed interpretation of this graph, refer to the Global Temperature Record Factsheet.

Part B: The Air That We Breathe

Step 1.

Let's start by giving students an idea of what 'parts per million' means. We'll do this by looking at the percentages of gases in our atmosphere. This will help students gain an understanding of why carbon dioxide is such a big deal - and why the 'Maths of Carbon' matters.

Place an empty glass or measuring beaker that is marked clearly into 10 intervals on a flat surface where all students can see it.

You can take a tall glass and mark it yourself into ten increments, like this:

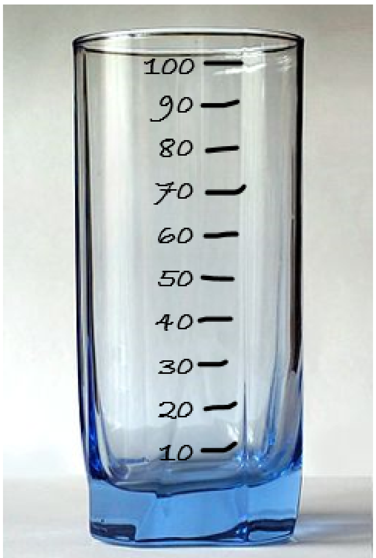


Image Credit: Creative Commons, (source)

Have a container filled with either water or, for effect, coloured liquid such as cordial.

1. Ask students, *“What would 10% look like in this glass?”* After receiving several answers, show them by filling the glass to the first (10%) increment.
2. Then ask, “*What would 50% look like?”* (repeat the procedure by filling to halfway); then *“What would 100% look like?”* (fill the glass all the way up).
3. Then ask students – *“How do we calculate ‘1%’?”*

After a brief discussion, remind students, if needed, that ‘1%’ is literally 1 out of 100. So, to find 1% of something, we calculate (1/100) x (the amount).

Importantly, ask students if they can figure out ‘1% of a million’. They can use a calculator if they’d like to.

Show students on the board that this is calculated as:

1⁄100 x 1 000 000 = 10 000

(or show the class on a digital calculator up on the electronic whiteboard if you have one).

“This means that 1 percent of one million is the same as ’10 000 parts per million’.”

Teaching Tip: Multiplying and dividing whole numbers by units of ten is a skill best taught alongside the rest of your teaching of multiplication and is a whole lesson - or series of lessons - in and of itself. This is because while many students understand place value as it relates to whole numbers, they struggle to apply this concept to decimal numbers. This is often because they have yet to grasp that decimal numbers are indeed fractions - in parts of tenths, hundredths, thousandths and so on. This **article** by Anne Roche explains how to assist students to make sense of decimal place value, in a 'game-ified' context.

Step 2.

Explain to students that our lesson today is going to be looking at the amount of some important gases in the atmosphere:

- *"In the clip from the film '2040', the narrator talked about 'parts per million' of gases in the Earth's atmosphere. This really means the percentages of gases in the atmosphere.*
- *"Scientists use the measurement 'Parts per Million' (abbreviated as 'PPM') as it's a little easier to say and explain, especially when we're talking about very large volumes of things - such as Earth's atmosphere!"*

If needed, show this short clip to help students better visualise the concept of 'parts per million'.

How to Visualise One Part per Million

Step 3.

Empty the marked glass back into the original container, then put up the following list on the board and explain to students that these are some of the important gases (but not the only gases) that make up our atmosphere. You can leave out the chemical symbols for each gas if you wish.

- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Water (H_2O)
- Nitrogen (N_2)
- Argon (Ar)

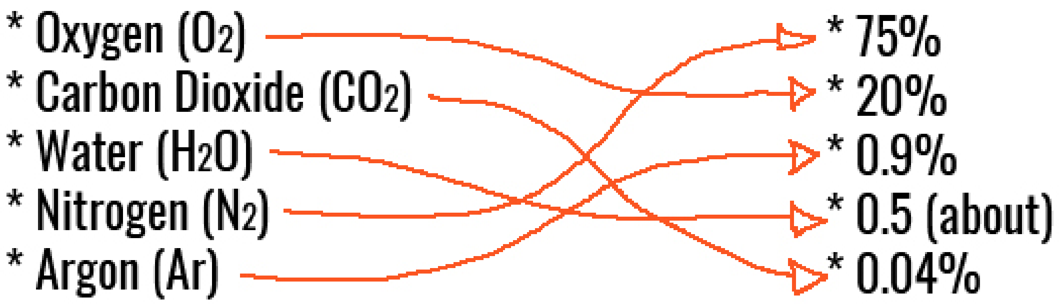
Stand on the Line

Using string, masking tape or chalk, create a line on the floor/ground long enough for all students to place themselves along. Explain to students that one end of the line is zero percent and the other end is 100 percent (consider using signs or writing on the board which end is which). Call each gas aloud, one at a time, inviting students to position themselves along the line based on how much of the gas they think is in the atmosphere.

After the students have had their guesses, write the following percentages next to the list of gases:

- Oxygen (O_2) **20%**
- Carbon Dioxide (CO_2) **0.04%** *(explain that this means much less than 1% - it's only 'four hundredths' of one percent)*
- Water (H_2O) **0.5%** *(about)*
- Nitrogen (N_2) **78%**
- Argon (Ar) **0.9%** *(explain that this is less than 1% - that is, it's 'nine-tenths' of one percent)*

You could also do this activity as a matching exercise, like so:



Step 4. Repeat the container activity using these percentages.

1. **Nitrogen – 78%** - or 780 000 parts per million (fill the glass to about 78%);
2. **Oxygen – 20%** - or 200 000 parts per million (fill the glass to about 98%);
3. **Argon – 0.9%** - or about 9 000 parts per million (fill the glass to about 99%);
4. **Water – 0.5%** – or 5 000 parts per million (fill the glass to about 99.5%);
5. **Carbon Dioxide – 0.04%** (splash a tiny dab of liquid into the top of the glass)

You might like to try doing this activity with different coloured rice (or similar). It will help students see each percentage as it is added and also help to illustrate the concept of 'parts per million' because there are many grains of rice in the container.

Step 5.

Have students fill in the below table on the Student Worksheet, calculating the parts per million of each gas, based on the percentages provided. Some assistance and scaffolding may be needed for some students here.

Name of Gas	Amount in Atmosphere - as 'Parts per Million' (PPM)	Amount in Atmosphere - as a Percentage (%)
Nitrogen	780 000	78 %
Oxygen	200 000	20 %
Argon	9 000	0.9 %

Water	5 000	0.5 %
Carbon Dioxide	400	0.04 %

Reference: Pidwirny, M. (2006). "Atmospheric Composition". Fundamentals of Physical Geography, 2nd Edition. **https://www.physicalgeography.net/fundamentals/7a.html**

To finish this section, explain the following:

- *Carbon dioxide gas really makes up only a tiny proportion of the gases we have in our earth's atmosphere. However, it has an enormously important job: It holds heat (or 'radiation energy') from the sun in our atmosphere, so the surface of the earth doesn't freeze. However, its tiny amounts – and the important job it does retaining the sun's heat – also means that the warmth of the earth's atmosphere is VERY sensitive to changes in the amount of carbon dioxide.*

Part C: Tracking The Earth's Atmospheric Carbon Record

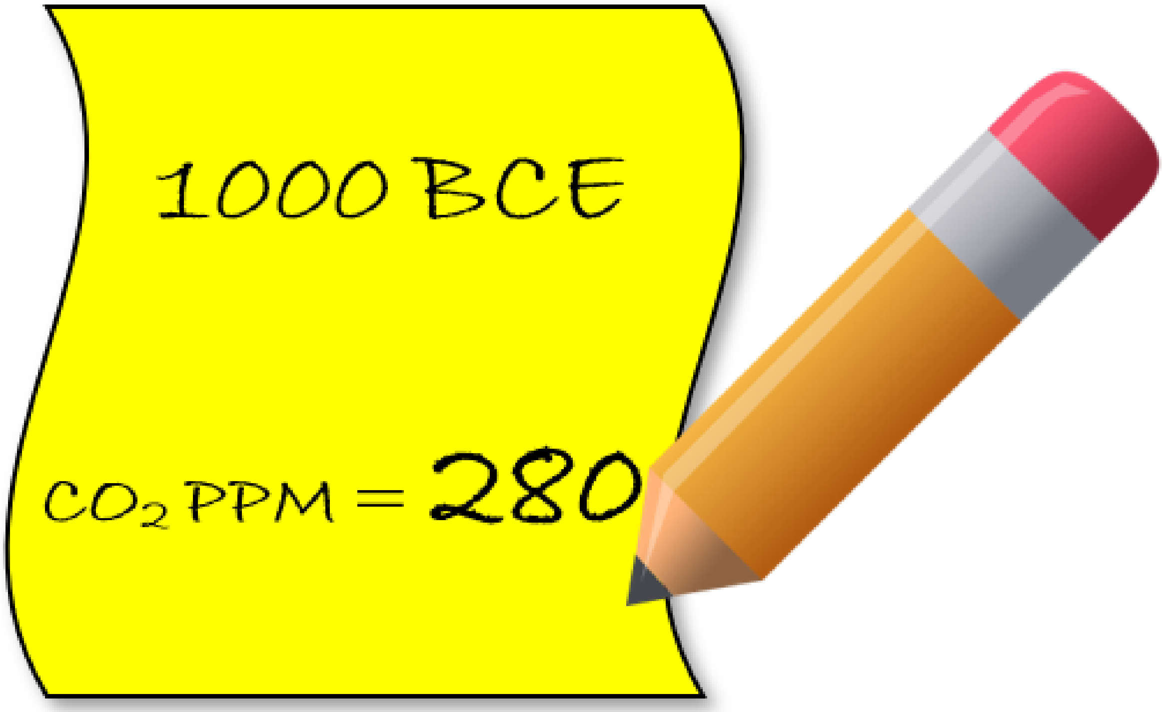
Step 1.

In this activity, we're going to make a large, representation of a graph showing the changes in carbon dioxide in Earth's atmosphere over the last 1,000 years. Tell students we're going to see what that looks like by making our own whole-class graph together.

You and your class will need to find **a large blank whiteboard, window or a large wall** in the classroom or in a hallway close by. You'll need to be able to write or draw on this space, so arm yourself with **a whiteboard marker** or some **chalk.**

You'll also need a **pad of sticky notes** so your students can write on them and then stick their data up to make the 'graph'.

Display the '**CO_2 Data Table**' (below) so students can see it. Allocate each student in your class or group to one (or more) data rows (or 'data points'). There are 28 data rows altogether; for classes or groups smaller than 28, allow some students to have more than one data row to their name.



The CO_2 Data Table below provides measurements of the amount of carbon in the atmosphere, expressed as ‘Parts per Million’ (PPM), on year dates between 1000 BCE (Before Common Era) and 2019 BCE*.

Write students' names next to the rows allocated to then - then have students write each of their allocated data points onto a separate sticky note like shown.

NOTE: We have mixed up the dates on purpose!

YEAR (BCE)	Atmospheric CO_2 Concentration (PPM)	Student/group name
1200	284	
1850	285	
1700	277	
1950	311	
1725	277	
1000	280	
1750	277	
1550	283	
1875	289	
1400	280	
1100	283	
1900	296	
1600	276	
1150	284	
1300	283	
2019	412	
1800	283	
2000	367	

1650	276	
1500	282	
1050	281	
1275	282	
1350	282	
1925	305	
1825	284	
1450	281	
1775	277	
1250	282	

**(Scientists are able to measure this by drilling down into the ice in the Antarctic and Arctic to make 'ice cores'. This allows them to study the chemical composition of ice as it was laid down over thousands of years, and so determine what was going on in the atmosphere during each 'age').*

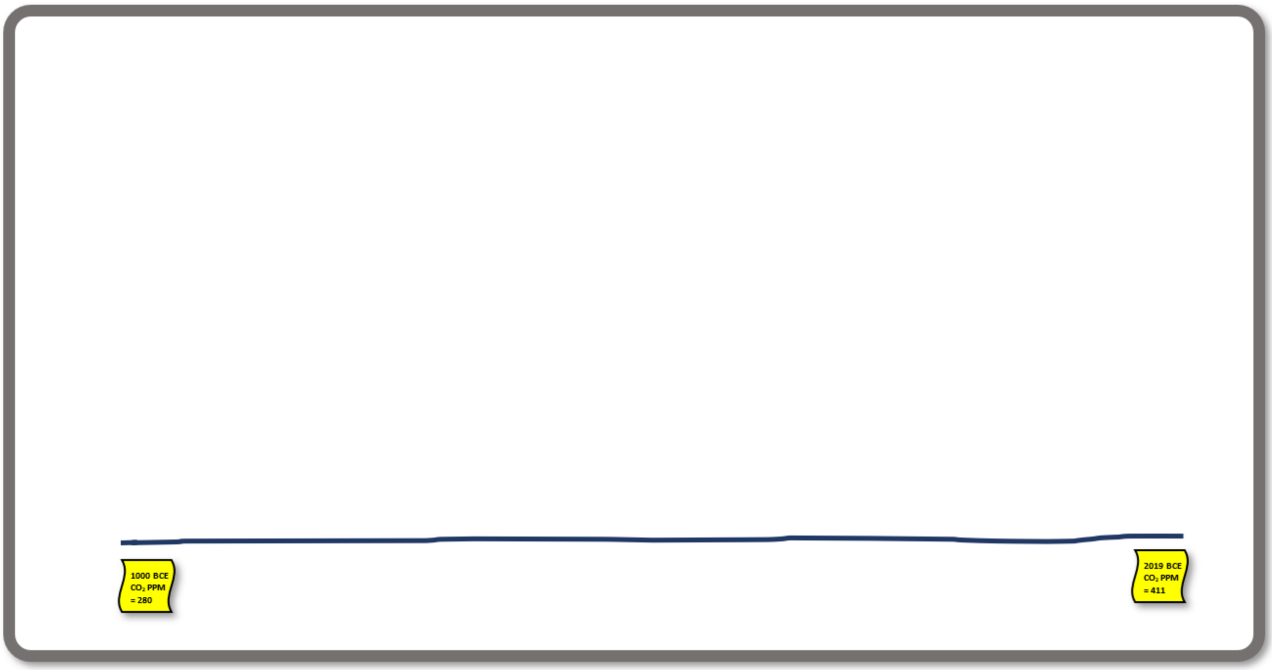
Once all the students have at least one sticky note each, ask the following questions of the group:

- *"What is the oldest year date we have?"* - 1050 (after this has been worked out, have this person stand up).
- *"Who has the latest or most recent date?"* - 2019 (have this person also stand up).

Step 2.

Invite these two students to walk to the wall or board and stick their dates at the bottom left-hand corner (oldest) and the bottom right-hand corner (latest) of the board, wall or window.

Then, draw a line just above these sticky notes - this will become the horizontal axis for your class's graph.



Now, have the class work out how we could place dates along the timeline you have drawn using regular or 'equal' intervals. "*How could we do this?"* Have students work out a strategy, and work with them (by scaffolding and prompting) to mark suitable date intervals onto the board or wall.

Once this is done, have students stick their sticky notes along their appropriate place on the 'timeline' they have made along the wall or board.

You might like to do this activity outside drawing the axis with chalk or strings. You could have students stand at their data point or lay down sports cones. For an extra challenge, get them to stand in the right spots on the graph WITHOUT talking.

Next, have the class look at the highest and the lowest CO_2 'PPM' levels.

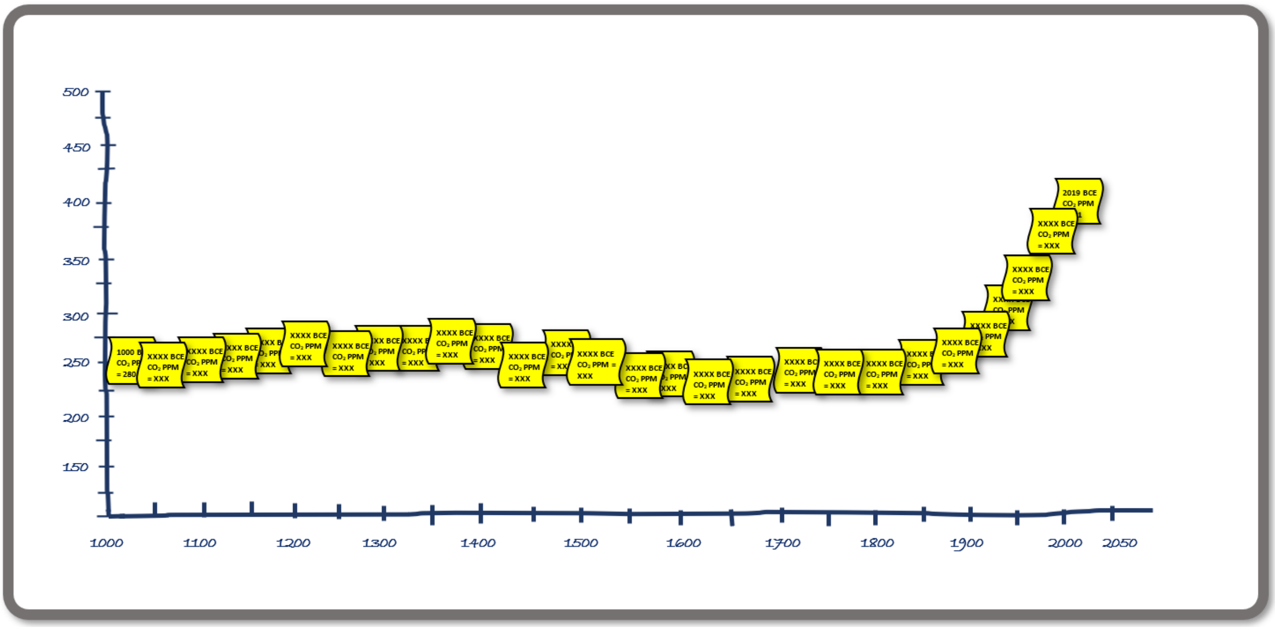
- *"What is the highest?"*
- *"What is the lowest?"*

Explain that to make a graph, we will also need to have a vertical scale - so stick the highest card up high on the board (still in line with its date on the horizontal axis!), and stick the lowest CO_2 value down lower (and also in line with its horizontal axis position).

Next, discuss with the class how we could make the vertical axis between those two values:

- *“What should be the lowest value on the vertical axis?”*
- *“Do we need to start with zero at the bottom? Why/Why not?”*
- *“If we don’t start at zero on our vertical axis, what do we need to be careful of?”*
- *“How can we mark out regular intervals on the left-hand side of our ‘graph’, making sure our ‘increments’ are even… and why is this important?”*

After your discussion, mark out the vertical axis of the graph.
Finally, have students move their sticky notes upwards until they are in the right vertical position, matching up with the new axis you have drawn up the left-hand side of the ‘graph’. Your class should have something that looks like this:



Make sure you snap a picture of your class’s terrific graph and then have students return to their regular learning space or classroom. Maybe you could even print out the photo of the graph and publish it on the learning space wall.

Step 3.

Having finished off the graph (and maybe making the odd tweak or adjustment), use the following class questions as your students stand around looking admiringly at the results of their teamwork. Use these to ‘prod and promote’ discussion:

- *“What kind of graph is this?”* (Line graph)
- *“How is this different from a column graph?”* (Column graphs have separate categories of data that we compare with one another. A line graph shows changes in one thing, usually over time, as a continuous series)
- *“Why is this type of graph being used?”* (Because we’re showing something changing gradually over time - not separate categories of things such as we would show in a column graph)
- *“What is shown on the horizontal and vertical axes of this graph?” (*Horizontal - years since 1000 BCE up until 2019; Vertical - CO_2 in the atmosphere as parts per million (PPM). Have a student write these labels on the graph)
- *“What label or heading could we give this graph?”* (Compose a suitable heading with student input, then write it above the graph on the wall or board)
- *“What does our graph tell us? What information does it give?”* (That atmospheric CO_2 in the Earth’s atmosphere has been pretty stable for the past 1000 years (and more!!), however, there has been a dramatic increase since the mid-1900s)
- *“Thinking about the video we have watched today, can we explain some possible reasons for this trend?”* (Refer back to the video - largely, this has been due to human activities burning fossil fuels and releasing large amounts of stored carbon into the atmosphere. Some explanation of the fact that coal, in particular, is stored carbon as it is made out of millions of years’ worth of compressed trees and carbon-based remains of other living things).

Reflection

At this point, it will be tempting for your students to express a sense of being overwhelmed. CO_2 in the atmosphere and global warming seems like a big and unstoppable problem!

Allow your students to complete the Think, Feel, Wonder activity on the Student Worksheet. Acknowledge their concerns as valid. Then remind (or inform) them that we have a few powerful solutions at our disposal:

- **Trees and Plants** (including other carbon-storing organisms such as seaweed) actually absorb carbon dioxide, ‘drawing it down’ from the atmosphere;
- **Renewable energy sources** - such as rooftop solar systems - significantly reduce the amount of carbon dioxide produced by our households; and
- **Reducing our energy consumption** - by using fewer electrical appliances (such as tumble dryers and extra freezers), we can significantly reduce the volume of CO_2 our household or family releases into the atmosphere.

In the following lesson, **2040 - Reducing Our Carbon Footprint - Years 5 & 6**, we're going to look at ways in which we can help to 'draw down' some of the Earth's atmospheric CO_2. We'll use maths to put some numbers around how great a difference some of the strategies can actually make - and so prove that mathematics really can help save the planet.

Differentiated Learning

Extension -

1. Students could work further through the 2^o Institute **website** and explore the graphs and data they collect on global temperatures, atmospheric and oceanic changes that are impacting global climates and environments. In particular, students could work through the following Inquiry Questions:

- What is a 'carbon footprint'?
- What is the difference between carbon, 'CO_2' and 'CO_2e'?
- What are the main components of a carbon footprint? Draw a table that summarises these components, including the amount of CO_2e each of these components contributes to overall human CO_2 emissions, measured in tonnes of CO_2e per person per year. Note that if you're using the data on this website (which is American), students will need to convert between American 'tons' into metric (Australian) 'tonnes'. (See **https://www.google.com/search?q=tons+to+tonnes+conversion**)
- Use the data and graphics on this website to construct a column graph for the classroom wall showing the main components of our carbon footprint in societies such as Australia and North America.

2. The images in this article from The Conversation, **Visualising Australia's Carbon Emissions** (https://theconversation.com/visualising-australias-carbon-emissions-23816), provide a good visual for the weight of the carbon dioxide that we produce per person, and each day, in Australia.

Here, CO_2 is measured in kilograms; you may need to explain here that even gas has a weight (has anyone in the class ever tried to lift a full barbecue gas bottle?). Gases - like CO_2 - are just less 'compressed' than solids and liquids. To give an idea, though, one kilogram of CO_2 takes up the same amount of space (at room temperature) as two full bathtubs, or the boot of a large car. (See **UMSL.edu - How much volume does a kg of CO2 occupy.**

3. For additional information on carbon consider showing students the following clip from 2040, **Soil Carbon Demo** **Password: 2040EDU** (https://vimeo.com/336508523)

Provisions for Learning Support -

- Pair students of differing ability in the warm-up and the whole-class graphing activity to assist students experiencing difficulty to gain support from peers with a stronger understanding
- Use simple scales (such as number lines or rulers) and timelines prior to constructing the graph to show evenly spaced increments and why this is important for accurate measurement. One-to-one correspondence on scales, timelines and graphical increments is an important precursor to understanding many-to-one correspondence (such as in the vertical axis in this graphing activity)
- Assisting students to break down larger numbers, such as the 'parts per million' measurement of CO_2, or year dates between labeled increments (eg. '1350 BCE'), using place value strategies. For example, 'we need to find the number '275' on this axis. Let's break down '275'... firstly, how many hundreds? Okay, let's find 200… Now, how many tens?..." etc.

Teacher Reflection

Take this opportunity to reflect on your own teaching:

- What did you learn about your teaching today?
- What worked well?
- What didn't work so well?
- What would you share?
- Where to next?
- How are you going to get there?

What's Your 2040?

Record your students' work in their communities with the hashtag #whatsyour2040 and share their visions in the '2040: **The Regeneration' Facebook Group**.

The 2040 crew would love to see your class's work.

These lessons have been created in partnership with

2040, Good Thing Productions