# Levels 9/10 Geography Activity

## Climate Change – Evidence, Causes, and Impact

## Introduction to Numeracy in Geography

A geographically-literate person understands space (location, distance, direction, pattern, shape, and arrangement) and place (relationships between physical and human characteristics). Space and place underpin all aspects of geographic study. To have geographical understanding is to understand location as well as the more multifaceted understanding and competence relating to the changing relationships between people, place, and the environment. To be geographically literate, one must be able to use mathematical skills to solve geographical problems. The term used to describe the use of mathematics in everyday life, and to appraise the use of mathematics for appropriateness, is *numeracy*. In geography, numeracy involves solving numerical problems and understanding the ways that numerical information is gathered by counting and measuring. Numeracy also involves understanding how data are analysed, described, and presented in graphs, charts, and tables. Thus, there is a wide range of knowledge, skills, behaviours, and dispositions relevant to geography that can be enhanced through developing numeracy. The geography curriculum is rich in opportunities for students to use their numeracy skills. By identifying the numeracy skills associated with the geography curriculum content, teachers can plan lessons to incorporate the development of the geographical skills through the application of numeracy skills.

A short audit of the numeracy demands relating to these understandings in Geography Years 7 to 10, as preparation for success in Year 11 and 12 Geography, highlights the following list of six competencies. Namely, students should understand:

* Percentage, rates, and proportion (e.g., per 1,000 as used in demography) and other quantifying numbers
* Statistics – basic survey skills, representation and interpretation of data, reading graphs (column, bar, pie, line, scatter, etc.) and trends in data
* Measurement – estimating and measuring area, distance, and height; comparing measurement units
* Numerical data on maps (proportional symbols, scale, position, location, etc.)
* Geometric properties
* Number patterns and algebraic thinking

Numeracy skills for deep understanding includes the effects of location, distance, and spatial distributions, and the design and management of space within a place. In the short audit, the following are all important geographical numeracy skills: counting, time, measurement, distance, area, scale, creating and analysing tables and graphs, and calculating and interpreting basic statistics.

In the Australian Curriculum, numeracy is one of seven general capabilities to be addressed through the learning areas. The key ideas for numeracy are organised into six interrelated elements in the learning continuum, and are readily aligned with geography:

* Using spatial reasoning
* Using measurement
* Interpreting statistical information
* Using fractions, decimals, percentages, ratios and rates
* Recognising and using patterns and relationships
* Estimating and calculating with whole numbers

## Developing Numeracy Understanding in Geography

In the Victorian Curriculum: Humanities (Geography), teachers are required to provide opportunities for students to develop geographical numeracy skills in an applied environment. Students need to be able to generate and analyse primary data, as well as analyse secondary data. Students need to construct and interpret graphs and maps, and describe space and place using latitude and longitude (Donnelly & Martin, 2018). However, students often fail to make progress in these concepts, especially when the focus becomes numerical (Davidson et al., 1998). In order to support students’ numeracy development in geography, it is important to:

* *Develop students’ mathematical and numeracy confidence* – teachers may have emphasised a right or wrong answer during prior mathematics learning experiences. By considering and fostering the development of Dweck’s (2006) growth mindset, students who have struggled in mathematics in the past can become more confident in using mathematics and increase their belief in their mathematical abilities.
* *Improve the perception of mathematics* – mathematics is sometimes considered as too abstract, and perceived unrelated to real life. This is often an artefact of students’ negative perceptions of mathematics transferred to their learning in geographical contexts. Teachers can help students to recognise that mathematics derives from sensible concepts and ideas, and underpins much of what we do in science and real life.
* *Use and explain mathematical language* – the use of mathematical conventions, symbols, and interpretation can be cryptic to many students. Misunderstanding may develop due to the presence of homonyms in mathematics that mean something quite different in science (e.g., product). Teachers should always explain terms, especially where they have multiple meanings.
* *Increase students’ familiarity with mathematical concepts and skills –* students may not have familiarity with a mathematics concept, which can cause problems for the geography teacher who might assume that students understand the concept. The most common problems relate to place value – large numbers, negative numbers, ratio, proportion, percentage, scale factor enlargement, scales, and compound measures.

Providing access to spatial technologies that facilitate interactions with real-world locations can often ameliorate these issues. For example, the use of virtual maps, satellite images, global positioning systems (GPS), geographic information systems (GIS), remote sensing, and augmented reality can aid students in visualising, manipulating, analysing, displaying, and recording spatial data (Catling & Willy, 2009). Goos et al. (2019) outline that attitudes are critical to developing numeracy across the curriculum. All teachers should reinforce positive feelings towards mathematics, encouraging students to use their numeracy skills to interpret geographical data. By not emphasising hand-drawing graphs, and instead using a spreadsheet program like Excel, time can be spent on understanding what the graphs and statistics mean. However, the teacher will need to ensure students understand the correct graph type to use and why. Discussing the link between the data in a spreadsheet format and the graphical display often leads to improved understanding of the issue being explored.

Data relating to students’ known experiences, which they have generated themselves, have a personal meaning and also contribute to a more positive attitude towards the use of mathematics concepts in geography.

## Lesson Plan: Climate Change – Evidence, Causes, and Impact

Numeracy skills naturally occur in the Biomes and Food Security, and Environmental Change and Managementsub-strands. The activities in this lesson plan relate to the analysis of representations of climate change data. The focus is on interpretation of graphical data and comparisons of maps. There is a plethora of graphical information available that can be used to explore the evidence, cause, and impacts of climate change. A numeracy focus on these data representations is essential, as students often struggle with learning to draw and interpret graphs effectively. The mathematics involved is sometimes a contributing factor, and, as a geography teacher, you may be concerned about your students learning the geography and the concepts involved with graphing the geographical data. Where students work with data or locations with which they are familiar, the data are personally meaningful and less abstract. As such, engagement in enhanced, as is the development of a deeper understanding of the geographical concept. In this example, we illustrate one activity relating to the impact of climate change. However, the recommendation is to work with students in relation to climate change evidence and causes, prior to exploring the impact. In evidence activities, students might examine area changes of snow and ice data on polar region maps. Emission data and an analysis of media reports can be used for exploring causes.

## Prerequisite/Co-requisite Knowledge: Geography

* Knowledge of the weather normally associated with the seasons of Summer, Autumn, Winter, and Spring
* Understanding of rainfall, its units of measurement, and people’s reliance on it
* Familiarity of temperature fluctuations (and the units of measurement for temperature) associated with seasons
* Basic graph reading skills and knowledge

## Background Mathematical Skills and Understandings

Geography teachers are not expected to teach the mathematical knowledge and skills that students will draw on when engaging with this activity. The students will have learnt and should be adept with the required mathematical knowledge and skills to complete the activity. According to the Victorian Curriculum Mathematics, the required mathematical knowledge and skills should have been developed in earlier years of schooling, that is, by the end of Level 8.

For this activity, the background mathematical knowledge and skills needed to complete the activity are:

* Knowledge of units of measurement – length, temperature, etc.
* Knowledge of the conversion of common metric units
* Knowledge of mean, median, and mode for a range of datasets
* Ability to interpret secondary data presented in digital media and elsewhere
* Ability to interpret, in context, data displays involving mean, median, and mode
* Ability to investigate the effects of individual data values, including outliers, on the range, mean, and median
* Ability to interpret and compare multiple data displays in context

Students may not have encountered box plots until Level 10. Also, if they have encountered box plots, quartile and interquartile ranges are more often used in mathematics. Thus, students may need assistance in understanding 10th and 90th percentiles.

## Lesson Description

For the climate change impact activity, use the Australian Government Climate Change in Australiawebsite (<https://www.climatechangeinaustralia.gov.au/en/>).

Use the Summary Data Explorer (<https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/summary-data-explorer/>). This site provides downloadable boxplots of eight projected climate variables (e.g., temperature, rainfall, humidity).

It should be noted, in the Victorian Mathematics Curriculum, the term *box plot* is used (Level 10, VCMSP351); however, on this website, the term *bar plot* is used. The webpage provides an explanation for interpreting the bar plots in terms of median, 10th percentile, and 90th percentile.

The climate projections are plotted as box plots for low greenhouse emissions (yellow) Representative Concentration Pathways (RCPs) RCP2.6, medium greenhouse emissions (blue) RCP4.5, and high greenhouse emissions (pink) RCP8.5.

The accompanying information to the explanatory box plot relates to:

1. The median value of the model simulations (20-year moving average climate); half the results fall above and half below this line
2. The range (10th to 90th percentile) of model simulations of 20-year average climate
3. The projected range (10th to 90th percentile) of individual years considering variability in addition to the long-term response (20-year average)

The recommendation is to select the temperature (surface seasonal air temperature, surface maximum seasonal air temperature, surface minimum seasonal air temperature) or rainfall climate variables, thenextract the relevant plots and make copies available to students for analysis, discussion and interpretation.

### Climate Change - Impact

It is important for the development of numeracy that students select and apply mathematics to topics relevant to local phenomena. In this activity, students will recognise the need for appropriate measurement units for temperature (°C) and rainfall (mm), and explore current recordings and future temperature and rainfall projections for Victoria.

1. As a class, explore the ‘explanation for interpreting the bar plots’ in terms of median, 10th and 90th percentile range, and projected range (see the Summary Data Explorer website: <https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/summary-data-explorer/>).

In the example of projected rainfall provided, draw students’ attention to the yellow, blue, and pink boxplots. These represent low, medium, and high greenhouse emission concentration pathways – identified using the industry-specific acronym RCP. By reading the side scale, or making a physical measurement of the boxes (using a ruler), students can gain an understanding of the predicated decline in rainfall if emissions continue to rise. The median value falls between 10 to 30% depending upon the RCP concentration pathway. The higher the RCP concentration pathway, the greater the rainfall reduction. The boxes show an increasing range between the 10th and 90th percentile with increasing concentration pathway. The length of the line segments decreases as the concentration pathway increases, indicating a decreasing year-to-year variability.

1. Allocate pairs and groups to representative concentration pathways (RCPs) greenhouse emission levels. Depending upon the size of the class and time available (i.e., number of lessons), half the students can investigate temperature and the other half can investigate rainfall. Ideally, you will have 12 students working on temperature (three pairs in Groups 2 and 3), and six students working on rainfall (three pairs in Group 4). For example:

* Group 1 Temperature
* Pair 1 representative concentration pathways RCP2.6 (yellow)
* Pair 2 representative concentration pathways RCP4.5 (blue)
* Pair 3 representative concentration pathways RCP8.5 (pink)
* Group 2 Maximum Temperature
* Pair 1 representative concentration pathways RCP2.6 (yellow)
* Pair 2 representative concentration pathways RCP4.5 (blue)
* Pair 3 representative concentration pathways RCP8.5 (pink)
* Group 3 Minimum Temperature
* Pair 1 representative concentration pathways RCP2.6 (yellow)
* Pair 2 representative concentration pathways RCP4.5 (blue)
* Pair 3 representative concentration pathways RCP8.5 (pink)
* Group 4 Rainfall
* Pair 1 representative concentration pathways RCP2.6 (yellow)
* Pair 2 representative concentration pathways RCP4.5 (blue)
* Pair 3 representative concentration pathways RCP8.5 (pink)

### Temperature Change

1. Explore the Temperature plot as a whole class (download from Summary Data Explorer: <https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/summary-data-explorer/>). Discuss the meaning of low (yellow) greenhouse emissions representative concentration pathways RCP2.6, medium (blue) greenhouse emissions representative concentration pathways RCP4.5, and high (pink) greenhouse emissions representative concentration pathways RCP8.5. This will be a recap of earlier work in the ‘Causes’ section of the unit.

* The temperature plot downloaded from the Summary Data Explorer website provides seasonal predictions (Summer, Autumn, Winter, and Spring) for four time periods. Discuss with the class what the patterns in the boxplots reveal. The temperatures will increase greatly with large seasonal ranges if the high concentration pathway (pink) is allowed to occur. Compare this to the remarkably consistent pattern for temperature, across the seasons, if low (yellow) concentration pathways are allowed to occur.
* Discuss box plot structures (median, 10th percentile, and 90th percentile). How can the size of the box and the lines best be described and compared?
* Students are able to measure (in mm) the sizes of the boxes and the line segments, to compare predicted ranges and outliers for low, medium, and high concentration pathways.
* The vertical axis on the plots can also be used to estimate ranges. However, the scale may be challenging for some students as substantial estimation is required.

1. In pairs, students analyse the box plot for their allocated representative concentration pathways RCP colour (yellow, blue, or pink; pre-download from Summary Data Explorer <https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/summary-data-explorer/>). Provide the students with an A4 sized printout or an iPad or laptop. Encourage accuracy of the measurement of each allocated box plot where students want to quantify size of boxes or lines. A clear plastic ruler should be used for measuring the lengths of boxes or line segments as the transparency of the ruler assists with alignment and reading of the measurements. Students can also use the ruler to add gradations on the y-axis to improve scale readability.
2. Create the groups of six students by combining three pairs (one for each concentration pathway).
3. As a small group, students share their box plot analyses and discuss apparent trends projected over time for low, medium, and high emissions.

### Rainfall Change

1. In pairs, students analyse the box plot for their allocated representative concentration pathways RCP colour (yellow, blue, or pink). Provide the students with an A4 sized print out or an iPad or laptop. Encourage accuracy of the measurement of each allocated box plot where students want to quantify size of boxes or lines. A clear plastic ruler should be used for measuring the lengths of boxes or line segments as the transparency of the ruler assists with alignment and reading of the measurements.
2. Create the groups of six students by combining three pairs (one for each concentration pathway).
3. As a small group, students share their box plot analyses and discuss apparent trends projected over time for low, medium, and high emissions.

### Temperature and Rainfall Change Relationships

1. Students share their temperature and rainfall interpretations so that the class discusses any relationships between temperature and rainfall impact.
2. Interpret any patterns and relationships from the Biomes and Food Security and Environmental Change and Management unit focus.

Table 1: Links to the Victorian Curriculum – Geography

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| Strand | Content Description (Code) | Elaboration(s) |
| Geographical Concepts and Skills | Identify, analyse and explain significant interconnections within places and between places over time and at different scales, and evaluate the resulting changes and further consequences (VCGGC129)  Analyse and evaluate data, maps and other geographical information using digital and spatial technologies and Geographical Information Systems as appropriate, to develop identifications, descriptions, explanations and conclusions that use geographical terminology (VCGGC132) | Using the concept of a system, to examine the interconnections between biophysical processes and the human actions and their underlying causes that generate environmental change, together with the consequences of these changes  Analysing environmental change, such as the clearance of vegetation or a plan for a vegetation corridor, using topographic maps and satellite images |
| Geographic Knowledge | Distribution and characteristics of biomes as regions with distinctive climates, soils, vegetation and productivity (VCGGK133)  The interconnection between food production and land and water degradation; shortage of fresh water; competing land uses; and climate change, for Australia and other areas of the world (VCGGK135)  Environmental, economic and technological factors that influence environmental change and human responses to its management (VCGGK145) | Examining the influence of climate on biomass production (as measured by net primary productivity) in different biomes  Exploring environmental challenges to food production from land degradation (soil erosion, salinity, desertification), industrial pollution, water scarcity and climate change  Identifying human-induced environmental changes, such as water and atmospheric pollution, loss of biodiversity, degradation of land, inland and coastal aquatic environments, and evaluating the challenges they pose for the sustainability of environmental functions  Discussing whether environmental change is necessarily a problem that should be managed |

Table 2: Links to the 21st Century Numeracy Model (Goos et al., 2014)

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| Aspect of the Model | How This Aspect is Addressed by the Lesson |
| Attention to Real-Life Contexts   * Citizenship * Work * Personal and Social Life | Students will apply the mathematics relevant to making predictions of temperatures and rainfall in Victoria. For example, they will recognise the need for appropriate measurement units when investigating temperature and rainfall and making linear measurements for size comparisons. |
| Application of Mathematical Knowledge   * Problem Solving * Estimation * Concepts * Skills | Students can make use of, and sense of, the mathematics represented in the box plots. Students will have interpreted the box plots using relevant mathematical knowledge relating the rainfall or temperature predictions. |
| Use of Tools   * Physical * Representational * Digital | Students can investigate predictive data with the use of representational (graphs) and digital (computers and iPads) tools. They will also use physical tools (rulers) for length measurement. |
| Promotion of Positive Dispositions   * Confidence * Flexibility * Initiative * Risk | Students will feel confident to show initiative to interpret the mathematics to predict future climate variables. Students will engage with unfamiliar representations of data. The links to real-life phenomena will enhance students’ disposition towards mathematics by exploring climate change impact. |
| Critical Orientation   * Interpreting Mathematical Results * Making Evidence-Based Judgements | Students will develop an interpretive, evaluative, and analytical stance towards their climate variable by providing explanations for the patterns observed. They will form evidence-based opinions and make judgements or decisions relating to the predicated climate changes. Using their critical orientation, students will be able to present alternative arguments by looking at relevant data and information in an informed way. |

## References

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