Teaching Climate Change Science in a Junior Secondary School Setting

GZ Science Resources

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Justification of the Pedagogical Tools: Preparation for Junior Secondary School Science teaching of Climate Change

Innovative Pedagogies: Teaching Climate Change Science in a Junior Secondary School Setting.

1. Introduction

1.1. This context-based Climate Change Teaching Unit is designed to be used within a Secondary School Junior Science programme. The Curriculum Levels (NZC) range from L3-5 (Ministry of Education, 2014), and would fit best within a year 9 Science class. Provisions have been made for extension activities, with some concepts that could lead onto L6 AOs. Therefore, the Unit could be adapted for use for a year 10 Science class, or possibly a project-based year 11 class. I have drawn on a comprehensive list of Achievement Objectives from all four strands of the Science Curriculum (Ministry of Education, 2014), to create an interdisciplinary context, bringing together the Life, Physical and Earth Sciences (Lambert, Lindgren, & Bleicher, 2012). The unit is flexible in length, and with additional suggested teaching options added, it could extend into a two term programme. The climate change context can be adapted to fit within a cross-curricular programme, and it is envisioned that many of the human societal issues of climate change impacts, community adaptation, and global mitigation policies could be covered in more depth by the Social Science and English curriculum. If climate change is to be taught as a stand-alone Science Unit, then these additional areas can still be well covered by the Science AOs.

1.2. Interwoven within this unit, is the expectation that students will be concurrently utilising digital workbooks, which will be created to provide literacy and cognitive/thinking tool activities, links to online resources, as well as collaborative tasks, based on appropriate climate change related text. My current digital educational platform incorporates the O365 office suite, and specifically the OneNote digital tool, however, Google Classrooms could offer a suitable alternative. Students will be self-paced with their digital work, and 'dip-into' their books as they require additional resources and information, either in class, or at home (Tullis & Benjamin, 2011). The OneNote books will also be the main portal for flipped-learning, when required, to supplement the learning in class (Roach, 2014). Digital workbooks are able to provide easily accessible extension work, for those students that would benefit from it. OneNote also has optional tools, such as immersive reader, and diction, for those students requiring extra support with their literacy. The digital tools are intended to be used for project work planning, research, and presentation, both individually and collaboratively. Many of the activities provide students with the choice to work on learning activities digitally, and they will have the flexibility to work towards their Success Criteria (LOs), provided as a 'Progress Tracker', in whichever method is preferred. The Success Criteria are structured around curriculum levels, so students are aware of the breadth of concepts they are working across, as well as the depth at which they are working. The Progress Tracker, as well as providing students with clarity around the body of work, will be used as a focus for feedback (Byrne, 2016), and provide data for the teacher, indicating which concepts require further coverage. Student's pre-entry data, including PAT stanines, and NZCER testing, will be analysed to indicate which individuals would benefit from extra support and resources, likewise for those that may need to be extended.

1.3. There were several factors driving the development of this particular unit on climate change. Firstly, climate change is a topic that, historically, has been thinly covered within the Science programme of the two schools that I have taught in. Both schools could be considered Traditional in their approach to Junior Science education. The three strands leading onto Senior Science classes; Chemistry, Biology, and Physics, have a focal role within the Junior Science programme, taught as standalone units consecutively, with Nature of Science AOs sprinkled throughout. The Planet Earth and Beyond strand has a cameo role, to provide short, but interesting, units of work, usually after the formal Junior Examinations have concluded. This unit fulfils my personal preference for a multi-strand contextual teaching unit, allowing for the interdisciplinary nature of climate change, while also including a large swathe of Nature of Science, in particular, 'Participating and Contributing', which has not found a ready home in many other units we teach. Secondly, climate change is a vital area of education for our current cohort of learners (Versprille et al., 2017), soon to become the policymakers, consumers, and activists of the next generation. If they arrive into adulthood, having never been exposed to the scientific knowledge base, forming the foundation of rational arguments for the causes, and subsequent solutions, of climate change, they negate their position as informed decision makers. Climate change is not merely a 'trendy topic', that schools can claim to be included within their curriculums, to fulfil their progressive goals of developing 21st Century Learners. Climate change awareness is empowering, immediate and relevant, and will focus on an issue that will affect all of the learners' lives at some stage in the future (National Research Council, 2012). Finally, a future aim of this

Unit is for sections of it to be integrated within a larger Cross-Curricular Program, called the 'Navigator Stream', which is being initiated in 2019 for several classes of year 9 students. A core of eight teachers, drawn from Science, Mathematics, Social Science and English, will design, and provide teaching, within four contextualised 'Subject' classes, over the course of the year. Building for an Innovative Learning Environment is planned to start near the end 2019 year, and this will be the eventual home of the Navigator Stream classes. All students are opt-in to this programme during the enrolment period, with no immediate plans to shift the remainder of the Junior Science Department into contextual teaching and learning.

1.4. Students require more than just a straight transmission of content knowledge, such as that collated in the previous phase, so they can effectively construct their own knowledge base (Kober, 2015). Innovation in Pedagogy calls for students to be able to manage, and actively participate, in their own learning (Peterson et al., 2018). Pedagogies need to move away from Teacher-Directed Learning, and make the learner the focus, with opportunities that create engagement, and participation (Kober, 2015). In preparation for the learner's future, education serves multiple functions, helping them "develop core knowledge [, as well as the] skills to be successful in work and life." (p. 34). Designing and introducing a completely new topic into a teaching programme, with a new set of tasks, skills and investigations, can be an exciting prospect, but also one that may present challenges not yet encountered (Byrne, 2016). This can be especially daunting for a teacher without a developed PCK (Shulman, 1987) in climate change, combining content and pedagogical knowledge, or the 'what to teach', and the 'how to teach'. A well-developed PCK allows a teacher to make choices from a vast range of strategies, and combine them into an effective teaching plan (Peterson et al., 2018). With this in mind, I have kept a core group of 'familiar' pedagogical techniques in this unit, adapted to the context, which have produced positive learning outcomes in the past, and 'peppered' it with some new tools and strategies I am keen to trial. Climate change teaching, by its very nature, is a global challenge for educators. Castek & Dwyer (2018) explain that effective teaching needs to ensure that students are able to develop as critical thinkers, "which can be fostered through authentic, real-world learning that connects the global to the local." (p. 75). The goal of this unit is to encourage the learners not only to construct knowledge about the science of climate change, but to become participants as well, in the global quest to find solutions.

2. Climate Change Unit Plan

List science strands covered: Nature of Science Living World Physical World Material World Planet Earth & Beyond	BIG IDEA: Climate change is the result of many interacting systems on Earth, and it is accelerating due to anthropogenic (human-caused) activities.	LEVEL: New Zealand Curriculum Level 3-5 YEAR: Mixed ability Year 9, with extension work
NZC (Science) STRANDS: List AOs covered in this unit (including additional opportunities and linked into Unit Plan)		
Level 3	Level 4	Level 5
Nature of science. *Students will:* 3.1. Understanding about science 3.1.a. Appreciate that science is a way of explaining the world and that science knowledge changes over time. 3.1.b. Identify ways in which scientists work together and provide evidence to support their ideas. 3.2. Investigating in science 3.2.a. Build on prior experiences, working together to share and examine their own and others' knowledge. 3.2.b. Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations. 3.3. Communicating in science 3.3.a. Begin to use a range of scientific symbols, conventions, and vocabulary. 3.3.b. Engage with a range of science texts and begin to question the purposes for which these texts are constructed. 3.4. Participating and contributing 3.4.a. Use their growing science knowledge when considering issues of concern to them. 3.4.b. Explore various aspects of an issue and make decisions about possible actions.	Nature of science. *Students will:* 4.1. Understanding about science 4.1.a. Appreciate that science is a way of explaining the world and that science knowledge changes over time. 4.1.b. Identify ways in which scientists work together and provide evidence to support their ideas. 4.2. Investigating in science 4.2.a. Build on prior experiences, working together to share and examine their own and others' knowledge. 4.2.b. Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations. 4.3. Communicating in science 4.3.a. Begin to use a range of scientific symbols, conventions, and vocabulary. 4.3.b. Engage with a range of science texts and begin to question the purposes for which these texts are constructed. 4.4. Participating and contributing 4.4.a. Use their growing science knowledge when considering issues of concern to them. 4.4.b. Explore various aspects of an issue and make decisions about possible actions	Nature of science. *Students will:* 5.1. Understanding about science 5.1.a. Understand that scientists' investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument. 5.2. Investigating in science 5.2.a. Develop and carry out more complex investigations, including using models. 5.2.b. Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables. 5.2.c. Begin to evaluate the suitability of the investigative methods chosen. 5.3. Communicating in science 5.3.a. Use a wider range of science vocabulary, symbols, and conventions. 5.3.b. Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy). 5.4. Participating and contributing 5.4.a. Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.
Living world *Students will*: 3.1. Life processes 3.1.a. Recognise that there are life processes common to all living things and that these occur in different ways. 3.2. Ecology 3.2.a. Explain how living things are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced. 3.3. Evolution 3.3.a. Begin to group plants, animals, and other living things into science-based classifications. 3.3.b. Explore how the groups of living things we have in the world have changed over long periods of time and appreciate that some living things in New Zealand are quite different from living things in other areas of the world	Living world *Students will:* 4.1. Life processes 4.1.a. Recognise that there are life processes common to all living things and that these occur in different ways. 4.2. Ecology 4.2.a. Explain how living things are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced. 4.3. Evolution 4.3.a. Begin to group plants, animals, and other living things into science-based classifications. 4.3.b. Explore how the groups of living things we have in the world have changed over long periods of time and appreciate that some living things in New Zealand are quite different from living things in other areas of the world.	Living world *Students will:* 5.1. Life processes 5.1.a. Identify the key structural features and functions involved in the life processes of plants and animals. 5.2. Ecology 5.2.a. Investigate the interdependence of living things (including humans) in an ecosystem.
Physical world *Students will:* 3.1. Physical inquiry and physics concepts 3.1.a. Explore, describe, and represent patterns	Physical world *Students will:* 4.1. Physical inquiry and physics concepts 4.1.a. Explore, describe, and represent patterns	Physical world *Students will:* 5.1 Physical inquiry and physics concepts 5.1.a. Identify and describe the patterns

and trends for everyday examples of physical phenomena, such as movement, forces, electricity and magnetism, light, sound, waves, and heat. For example, identify and describe the effect of forces (contact and non-contact) on the motion of objects; identify and describe everyday examples of sources of energy, forms of energy, and energy transformations.	and trends for everyday examples of physical phenomena, such as movement, forces, electricity and magnetism, light, sound, waves, and heat. For example, identify and describe the effect of forces (contact and non-contact) on the motion of objects; identify and describe everyday examples of sources of energy, forms of energy, and energy transformations.	associated with physical phenomena found in simple everyday situations involving movement, forces, electricity and magnetism, light, sound, waves, and heat. For example, identify and describe energy changes and conservation of energy, simple electrical circuits, and the effect of contact and non-contact on the motion of objects. 5.2. Using physics 5.2.a. Explore a technological or biological application of physics
Material world *Students will:* 3.1. Properties and changes of matter 3.1.a. Group materials in different ways, based on the observations and measurements of the characteristic chemical and physical properties of a range of different materials. 3.1.b. Compare chemical and physical changes. 3.2. Chemistry and society 3.2.a. Relate the observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.	Material world *Students will:* 4.1. Properties and changes of matter 4.1.a. Group materials in different ways, based on the observations and measurements of the characteristic chemical and physical properties of a range of different materials. 4.1.b. Compare chemical and physical changes. 4.2. The structure of matter 4.2.a. Begin to develop an understanding of the particle nature of matter and use this to explain observed changes. 4.3. Chemistry and society 4.3.a. Relate the observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.	Material world *Students will:* 5.1. Properties and changes of matter 5.1.a. Investigate the chemical and physical properties of different groups of substances, for example, acids and bases, fuels, and metals. 5.2. The structure of matter 5.2.a. Describe the structure of the atoms of different elements. 5.2.c. Distinguish between an element and a compound, a pure substance and a mixture at particle level. 5.3. Chemistry and society 5.3.a. Link the properties of different groups of substances to the way they are used in society or occur in nature.
Planet Earth and beyond *Students will:* 3.1. Earth systems 3.1.a. Appreciate that water, air, rocks and soil, and life forms make up our planet and recognise that these are also Earth's resources. 3.2. Interacting systems 3.2.a. Investigate the water cycle and its effect on climate, landforms, and life. 3.3. Astronomical systems 3.3.a. Investigate the components of the solar system, developing an appreciation of the distances between them.	Planet Earth and beyond *Students will:* 4.1. Earth systems 4.1.a. Develop an understanding that water, air, rocks and soil, and life forms make up our planet and recognise that these are also Earth's resources. 4.2. Interacting systems 4.2.a. Investigate the water cycle and its effect on climate, landforms, and life. 4.3. Astronomical systems 4.3.a. Investigate the components of the solar system, developing an appreciation of the distances between them.	Planet Earth and beyond *Students will:* 5.1. Earth systems 5.1.a. Investigate the composition, structure, and features of the geosphere, hydrosphere, and atmosphere. 5.2. Interacting systems 5.2.a. Investigate how heat from the Sun, the Earth, and human activities is distributed around Earth by the geosphere, hydrosphere, and atmosphere.
INTENDED LEARNING OUTCOMES: List what learning outcomes could be achieved under the following headings:		
Conceptual LOs	Nature of Science LOs	Technical/skills LOs
O 1.2.1. Students can define, and state the key differences between weather and climate O 1.3.2. Students can describe some changes that occur within the five components of climate, which lead to climate change O 1.3.3. Students can describe some examples of interactions between climate components that influence climate, and they can identify some examples. O 1.3.4. Students can explain how human activity can influence the components of climate (extension) O 2.1.3. Students can describe where some of different forms of carbon compounds are found on Earth, and explain some of the processes that created them.	O 1.1.1. Students explore their prior knowledge about climate change. O 1.1.2. Common misconceptions about climate change are discussed, and alternative ideas are presented for students to consider. O 2.1.1. / 2.1.2. Students can draw, and construct models, name and give the symbol for carbon and some of the simple compounds it forms on Earth O 3.1.5. Students can conclude that darker surfaces absorb more energy from the Sun, and reflect less light, leading to an increase in the Earth's energy budget. O *3.2.4. Students explore the relationships between ocean surface temperature and levels of atmospheric carbon dioxide and water vapour. (extension)*	O 1.2.2. Students are able to use a thermometer and rain gauge to correctly observe, and record, daily weather readings. O 1.3.1. Students can label the five components of climate as the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere. O 2.1.1. / 2.1.2. Students can draw, and construct models, name and give the symbol for carbon and some of the simple compounds it forms on Earth O 2.2.1. / 2.2.2. Students are able to define, and label, carbon sources, sinks, and reserviours in a carbon cycle. O 3.1.4. Students can complete an Energy Earth budget, and calculate NET

O 2.2.3. Students can identify which processes in the carbon cycle are influenced by human activity, especially those that add CO_2 to the atmosphere. O 2.2.4. Students can compare pre-industrial to present day movement of carbon around the carbon reserviours. O 3.1.1. Students can explain that shortwave energy, in the form of light, radiates from the Sun, and is absorbed by Earth's surface. O 3.1.1. Students can explain that the cooler Earth surface radiates long wavelength energy in the form of heat. O 3.1.4. Students can link the temperature of the Earth's surface to the balance between incoming shortwave radiation (light) and outgoing long wavelength radiation (heat) O 3.2.1. Students can explain the importance of the greenhouse effect in keeping the Earth at a temperature suitable for life, and that some gases, called greenhouse gases, in the atmosphere can affect that energy balance, by absorbing heat (and some light) O 3.2.2. Students can understand why some gases in the atmosphere, such as CO_2, CH_4 and H_2O, act as greenhouse gases, while others, such as N_2 and O_2, do not. O 3.2.3. Students can link the presence of more CO_2 in the atmosphere, to more energy being retained around Earth, and hence an overall increase in average temperature. O 4.1.3. Students can link human activity to the most recent rapid increase in CO_2 in the atmosphere. O 4.2.1. Students can identify some of the consequences of climate change, including increasing temperature, changing precipitation patterns, sea level rise, and increasing frequency of extreme weather events. O 5.1.1. Students can identify some effects to ecological systems, and the species within them, caused by climate change, both in the present, and most likely in the future. O 5.1.1. Students describe a number of adaptation strategies, which can be used, or developed, to assist species to adjust to the present, and future, climate change challenges.	O 4.1.1. Students can observe that scientists use a range of methods to collect atmospheric CO_2 data, both from prehistoric and contemporary times. O 4.2.1. Students are able to make evidence supported claims from observed and predicted data and models. O 4.2.2. Students can conclude that only the melting of land ice, including the ice shelves in Antarctica, Greenland, and glaciers, contribute to sea level rise, NOT sea ice, such as that in the Arctic circle. O 5.2.1. Students can describe some New Zealand species affected by climate change, and identify possible adaptation strategies that can be planned and/or implemented to help them better cope with changes to their environments. O 5.2.2. Students can describe some New Zealand human communities affected by climate change, and identify possible adaptation strategies that can be planned and/or implemented to help them better cope with changes to their environments. O 6.1.1. / 6.1.2. Students investigate, and contribute to, some mitigations actions that are being undertaken, both globally and locally, which reduce the factors contributing to climate change. O 6.1.3. Students work in groups to decide on appropriate mitigation strategies (at governmental level), and justify their decisions O 6.1.4. Students explore how solar radiation, Earth's surface and oceans, and greenhouse gases interact to cause global warming. Students change variables to determine how much greenhouse gas emissions might need to fall to mitigate the temperature increase. O 6.2.1. / 6.2.2. Students describe some daily actions, which create their carbon footprint, and identify small changes that can be made to reduce it. O 7.1.1. Students can co-construct a feedback and assessment rubric O 7.1.1. Students can select, adapt, create or plan a feasible mitigation project O 7.1.2. Students are able to action a feasible small mitigation project. O 7.2.2. Students can reflect on their learning and engagement in this climate change unit.	energy gain, linking it to an increase of temperature O 4.1.2. Students are able to correctly graph provided data on atmospheric carbon dioxide concentration O 7.2.1. Students are able to clearly present their mitigation projects, explaining their goal and outcome, and how the project has contributed towards climate change mitigation.

<table>
<tr><th colspan="2">MANAGEMENT/MATERIALS:</th></tr>
<tr><td>Resources

O Climate Resources booklet (GZ) containing self-developed worksheets and activities
O Connected devices with Microsoft O365 / OneNote (or Google classrooms)
O Prepared OneNote workbooks for students with notes and literacy activities, and prepared collaborative literacy/multi-media tasks, and glossary
O Teacher prepared class presentation/slides ppt
O Progress sheet (paper or digital on OneNote)
O Field trip RAMS forms and planning preparation (Zoo, community mitigation group, etc.)</td><td>Artefacts

O Investigation equipment from school lab (listed in unit)
O Found activities from NEED www.need.org
O Thin ice documentary https://thiniceclimate.org/ and ice core collections videos
O Found activities from Arkive www.arkive.org
O Save the climate game printed (link in unit)
O Requested resources for individual projects</td></tr>
<tr><td colspan="2">ASSESSMENT/EVALUATION: Activities/tasks:

Formative

O 1.1.1. Climate change "Cartoon Concepts" scenario
O 1.2.1. Weather or Climate? sorter activity
O 1.2.1. Weather and Climate Venn diagram activity
O 1.2.2. OneNote digital weather diary (to be graphed later in the unit)
O 1.3.2. Climate features
O 1.3.3. Concept mapping
O 1.3.4. Climate features, and human influence activity
O 2.1.3. Carbon on Earth activity
O 2.2.2. Carbon cycle model
O 2.2.4. NEED "Carbon Cycle Simulation" card game
O 3.1.4. Earth's energy budget calculations
O 3.1.5. Albedo Effect investigation
O 3.2.3. NEED Greenhouse in a bottle investigation
O 4.1.2. "How much CO_2?" carbon dioxide concentration data graphing activity
O 4.2.1. Impacts on physical systems data activity
O 4.2.2. Land and Sea Ice investigation
O 5.1.1. Our homes are changing activity – ecosystems
O 5.1.1. Arkive "climate change activity"
O 5.2.1. NZ adaptation strategies card activity
O 6.1.3. Pangea 'middle school' mitigation activity
O 6.2.1. 'Save the climate' game
O Online assessment throughout unit with Education Perfect and OneNote literacy, cognitive/thinking tools and collaborative activities (self-paced)

Summative assessment

O 7. Students, with support, will design their own small group, or individual, climate change mitigation project, research, or initiative, which they will action and/or present to an audience. (Rubric co-constructed)</td></tr>
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Macro Task: 1. Unpacking Climate Change misconceptions held by students, and understanding what drives Earth's climate.					
Meso	**Micro**	**Organisational Frame**	**Focal Artefacts**	**Planned Interactions**	**Key Outcomes What do I Expect**
O 1.1. Students identify their prior knowledge, and consider some of the main misconceptions about climate change. (NoS 3.1.a., 4.1.a., 3.2.a., 4.2.a, 3.3.b., 4.3.b.)	O 1.1.1. Students participate in a "Cartoon Concepts" activity to share their prior knowledge about climate change O 1.1.2. Students contribute to a class discussion, which help to identify any misconceptions about Climate Change	O 1.1.1. Students work in small groups to discuss and record ideas O 1.1.2. Groups chosen by teacher in turn to present to whole class	O 1.1.1. Climate change "Cartoon Concepts" scenario card sets (GZ - adapted) O 1.1.2. "Scientist Says" class slide set (GZ)	1./ Handout sets of 1.1.1. climate change cards (laminated) to small groups (2-3) 2./ Students, in groups, read each card scenario, and discuss which idea they agree with the most 3./ Students record their thinking and explanation for each card. 4./ Groups, in turn, present one scenario card, with their explanation to the whole class. Other students encouraged to ask each group questions. 5./ Teacher encourages a classroom discussion after each scenario, with 1.1.2. Scientist Says slides.	O 1.1.1. Students explore their prior knowledge about climate change. O 1.1.2. Common misconceptions about climate change are discussed, and alternative ideas are presented for students to consider.
O 1.2. Students will be able to differentiate between weather and climate (PE&B 3.2.a., 4.2.a., 5.2.a.) *[Optional: opportunity to cover water cycle (PE&B 3.2.a., 4.2.a.)]* *[Optional: opportunity to cover states of matter and particle theory (MW 4.2.a., 5.3.a.)]*	O 1.2.1. Students use a Venn diagram, to differentiate between the terms weather and climate O 1.2.2. Students collect weather data using a diary and compare to local climate averages	O 1.2.1. Working in pairs, then larger groups O 1.2.1. Working in collaborative groups online O 1.2.1. Whole class discussion O 1.2.2. class demo O 1.2.2. Working individually to collect and record data	O 1.2.1. Weather or Climate sorter activity - paper and digital (GZ-adapted) O 1.2.1. Venn diagram page (on OneNote collaboration page) O 1.2.1. readwritethink compare and contrast map tool <https://bit.ly/R9IecS> O 1.2.2. MeteoEarth <https://bit.ly/1Dn46JB> O 1.2.2. OneNote digital weather diary (adapted) O 1.2.2. Climate data from NIWA <https://bit.ly/2y67x8v>	1./ Handout 1.2.1. weather or climate sorter activity to pairs, once finished they can combine with another group to discuss and compare. Combined answers in 2 columns (weather/climate) 2./ Students use 1.2.1. Venn diagram (weather/climate), as a collaboration activity (could use OneNote) using information from the previous activity to start developing ideas on the differences and similarities between the two. 3./ Paragraphs can be constructed using the 1.2.1. readwritethink compare and contrast map tool. (teacher supported) <https://bit.ly/R9IecS> 4./ Demonstrate how a (outside) thermometer and rain gauge are used to make weather observations. 5./ Use 1.2.2. Meteo Earth model to show current weather patterns <http://www.meteoearth.com> 6./ Students begin a 3 week 1.2.2. weather diary (On paper or OneNote) of their local weather, from class 'weather station' (at the same time each day), or from programs such as windy.com. This will be compared to average climate data from weather and climate from NIWA <https://bit.ly/2y67x8v> 7./ At the end of the 3 week period, a lesson can be set aside to graph both collected (and averaged) class weather data, and average climate data. Students may wish to add to their Venn diagram (1.2.1.).	O 1.2.1. Students can define, and state the key differences between weather and climate O 1.2.2. Students are able to use a thermometer and rain gauge to correctly observe, and record, daily weather readings.

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 1.3. Students will be able to understand how the five components of climate interact, (and how human activity can influence these components – Extension) (PE&B 3.2.b., 4.2.b., 5.2.a, NoS 3.3.b., 4.3.b.) *[Optional: opportunity to introduce seasons, as a source of climate variation and/or sun spots (PE&B 3.3.a., 4.3.a., 5.2.a.)]* *[Optional: opportunity to cover Earth's major biomes (LW 3.2.a., 4.2.a.]*	O 1.3.1. Students identify components in a climate system model O 1.3.2. Students identify some changes occurring within the components in a climate system model O 1.3.3. Students identify some examples of interactions between components in the climate system. *O 1.3.4. Students describe how human activity can influence climate components interactions (extension)*	O 1.3.1. Group / class discussion O 1.3.2. Working individually on paper, or digitally O 1.3.3. Whole Class activity O 1.3.3. Individual digital activity O 1.3.3. individual or small group activity *O 1.3.4. Working individually on paper, or digitally*	O 1.3.1. Climate model diagram O 1.3.2. / 1.3.3. Climate features diagram (GZ - adapted from IPCC) O 1.3.3. StudyJams Weather and climate https://bit.ly/16gvWI3 O 1.3.3. large paper for concept mapping or digitally https://bubbl.us *O 1.3.4. Climate features, and human influence chart (GZ - adapted from IPCC)*	1./ printed 1.3.1. Climate model diagram (and/or on ppt slides) given to small groups. Students identify main areas (components) that they consider could influence climate. Following on students discuss what type of changes could occur within each of those components. 2./ Students Label 1.3.2. climate features diagram to show components 3./ 1.3.3. Class role-play. 5 students can represent the five components and stand round in a spaced out circle. They can hold a ball of string/wool each. Students from the class suggest a component starter, and a component finisher, with the named interaction. Suggestions are on 1.3.2. The students connects the two with string/wool. This can be continued for a number of rounds so the class can see the numerous interactions involved in climate components. Students complete interactions on 1.3.2. 4./ Online 1.3.3. weather and climate StudyJams, animated interactive (OneNote linked) https://bit.ly/16gvWI3 5./ Begin a glossary of climate change in their OneNote After class discussion, list words on board that have been covered in past lessons, and including components of climate. This will be added to throughout the unit. 6./ 1.3.3. Concept mapping can be used at this stage to support the student understanding of climate and weather. Provide key words (and from glossary), and students have their previous work to draw on. Students can work on A3 paper in pairs, and digital mapping programs are also an option, such as https://bubbl.us *7./ (Extension) activity 1.3.4. for students to suggest how human activity may influence the interactions between the components*	O 1.3.1. Students can label the five components of climate as the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere. O 1.3.2. Students can describe some changes that occur within the five components of climate, which lead to climate change O 1.3.3. Students can describe some examples of interactions between climate components that influence climate, and they can identify some examples. *O 1.3.4. Students can explain how human activity can influence the components of climate (extension)*

Macro Task: 2. Explore and explain how carbon cycles throughout the Earth's systems, and how human activity affects the rate of transfer of carbon from one carbon reserviour (store) to another.					
Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 2.1 Understand the structure of carbon, and identify some common carbon compounds on found on Earth, and the processes to create them. (MW 3.1.a, 4.1.a, 3.2.b, 4.2.b. NoS 3.2.b., 4.2.b.) *[Optional: opportunity to cover carbon chemistry and fuels, coal and oil formation (MW 5.1.a, 4.3.a., 5.3.a), and rock cycle (PE&B 3.1.a, 4.1.a)]*	O 2.1.1. Students locate carbon on the periodic table, and write the chemical symbol O 2.1.2. Students use molymods to construct models of CO_2 and CH_4, and write their formula and name. O 2.1.3. Students identify where different forms of carbon might be found on Earth, and by what processes they were formed	O 2.1.1. Students work in small groups with periodic tables and molymods O 2.1.3. Students work individually on their carbon on Earth sheets	O 2.1.1. Periodic table (class set) O 2.1.2. Large plastic molymod sets (class set) O 2.1.2. Samples of different carbon and carbon compounds O 2.1.3. Carbon on Earth worksheet (GZ)	1./ Think-pair-share, then class discussion about where, and in what forms we would find carbon on Earth. Write the main points on the board. Conceptual diagrams can be constructed by students. 2./ Provide small groups with 2.1.1. periodic table. Students are to locate C (and O, H), and with 2.1.2. plastic molymods, make CO_2, and CH_4 (formula written on board) 3./ Show samples 2.1.2. of carbon (coal, graphite) and carbon compounds, if you have some available. 4./ Use the information from the board, research on their devices, and their models, to complete 2.1.3 Carbon on Earth *5./ (Extension) – research of uses of carbon, and carbon compounds, to humans*	O 2.1.1. / 2.1.2. Students can draw, and construct models, name and give the symbol for carbon and some of the simple compounds it forms on Earth O 2.1.3. Students can describe where some of different forms of carbon compounds are found on Earth, and explain some of the processes that created them.

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
❍ 2.2. Students describe how carbon cycles throughout the Earth's systems, comparing pre-industrial and present day movement of carbon. (PE&B 3.1.a., 4.1.a, 5.1.a, NoS 3.2.b., 4.2.b.) *[Optional: opportunity to cover combustion engines and coal powered electrical generators (PW 5.2.a)]* *[Optional: opportunity to cover photosynthesis and respiration. (LW 3.1.a, 4.1.a, 5.1.a)]* *[Optional: opportunity to cover decomposers and food webs. (LW 3.2.a, 4.2.a, 5.2.a)]*	❍ 2.2.1. Students define "carbon sources', 'carbon sinks' and carbon reserviours (stores). ❍ 2.2.2. Students use a carbon cycle model to label each carbon reserviour (store), and identify whether it acts as a carbon sink or a carbon source. ❍ 2.2.3. Students identify carbon sources created by human activity. ❍ 2.2.4. Students compare the rate of transfer of carbon between reserviours in the pre-industrial revolution period, and present day	❍ 2.2.1. Students work in pairs for think-pair-share ❍ 2.2.2. Students work in pairs, or individually, on the carbon cycle diagram ❍ 2.2.2. Whole class activity ❍ 2.2.3. Individual digital activity ❍ 2.2.4. Individual completion of carbon cycle diagram *❍ 2.2.4. Individual online writing prompter activity*	❍ 2.2.2. / 2.2.3. Carbon cycle model (GZ) ❍ 2.2.3. The Habitable Planet Carbon cycle simulator https://bit.ly/1qirgul ❍ 2.2.4. NEED "Carbon Cycle Simulation" card game (found game) https://bit.ly/2y7Vk3b ❍ 2.2.4. two or more packs of playing cards *❍ 2.2.4. readwritethink compare and contrast map tool https://bit.ly/R9IecS*	1./ 2.2.1.Think pair share on each of the terms : sources, sinks, reserviour (store) 2./ Discuss, and co-create a definition for each that can be added to their digital glossary. 3./ Project carbon cycle (simple) onto board (ppt), and with student input, add labels. 4./ Students use the 2.2.2. carbon cycle model to complete (either digital or paper) 2 levels for students 5./ 2.2.3. Carbon cycle simulator - adjust the amount of CO_2 emissions and relate that to changes in the carbon cycle https://bit.ly/1qirgul 6./ Discuss which processes may be influenced by human activity – students add to their diagrams. *7./ (Extension) Using the "carbon on Earth" worksheet competed previously, students can add the forms of carbon (formula) found in each reservoir.* 8./ Teacher provides explanation of the 2.2.4. NEED carbon cycle simulation game, handing out instructions, cards, posters and worksheets. https://bit.ly/2y7Vk3b This is a role playing game, where the students are 'carbon atoms' – they are originally assigned into 1 of 6 reserviours. At each reserviour each student draws a card. Rules at each reserviour tell the students where to go next. Students record movement. This is repeated for 10 rounds. 9./ Present day activity can be left for the second day. Repeat as above. 10./ When completed, students can work in small groups to summarize data, followed by whole class discussion. 11./ Students can then add extra detail (in 2 different colours) to their carbon cycle diagram. *12./ (Extension) An additional activity on www.readwritethink.org is to use the compare and contrast format, to compare between pre-industrial and post-industrial sources of carbon.*	❍ 2.2.1. / 2.2.2. Students are able to define, and label, carbon sources, sinks, and reserviours in a carbon cycle. ❍ 2.2.3. Students can identify which processes in the carbon cycle are influenced by human activity, especially those that add CO_2 to the atmosphere. ❍ 2.2.4. Students can compare pre-industrial to present day movement of carbon around the carbon reserviours.

Macro Task: 3. Understand the inputs and outputs that contribute to the Earth's energy budget, and the role of the Greenhouse Gases in creating the Greenhouse Effect					
Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 3.1. Students understand how energy moves into, and out of Earth, to produce an Energy budget (PE & B 5.2.a, PW 4.1.a., 5.1.a, NoS 3.2.b., 4.2.b., 5.2.a.) *[Optional: opportunity to cover other aspects of light properties. (PW 3.1.a., 4.1.a, 5.1.a.)]*	O 3.1.1. Students use Slinkys to demonstrate that energy travels in waves, linking short wavelengths (Light) to containing more energy than long wavelengths (Heat) O 3.1.2. Students identify the sources, and types of energy, that move around the Earth. O 3.1.3. Students define the following terms: energy transformation, absorption, emitting, short wave radiation, long wave radiation O 3.1.4. Students observe an energy balance demo, and then use data to create an input/output model of energy budget for the Earth.	O 3.1.1. Whole class activities. O 3.1.2. Individual digital activity O 3.1.3. Individual work O 3.1.4. Class demonstration O 3.1.4. Individually calculating energy budget	O 3.1.1. Slinky O 3.1.1. Electro-magnetic spectrum chart. O 3.1.2. Energy on Earth interactive https://bit.ly/1z6404s and teacher demo https://bit.ly/2DhDeeD (hide the math) O 3.1.4. plastic bucket (+ water tap/sink) for demonstration or simulation https://bit.ly/2o2hzUu O 3.1.4. Earth's energy budget sheet (GZ)	1./ Use the slinky, with students holding either end, to demonstrate how waves (transverse) travel along it. Move the slinky quicker (up and down) to create shorter wavelengths (frequency) to show the students the more energy you put in to make the slinky move faster, the shorter the wave length. Repeat at slower speed to produce longer wavelengths. 2./ Display the 3.1.1. EMS chart (ppt) to students, discuss that most energy released from the Sun, travels to earth as SW light, and most travels straight through to Earth's surface. (go outside – see light coming from Sun), is absorbed by earth, and most is re-radiated back from earth as LW energy (heat). 3./ Students identify types and sources of energy on earth using 3.1.2. energy on earth interactive https://bit.ly/1z6404s 4./ Discuss definitions: energy transformation, absorption, emitting, short wave radiation, long wave radiation: that students add to their OneNote glossary. 5./ 3.1.4. Demonstration of energy equilibrium: Place a small plastic bucket with small holes over tap with string. Fill with half way with water. Run water into the bucket at the same rate it runs out – this may take a little time to establish. Explain to students that when the same amount of water (representing light (SW) energy from the sun) equals the amount of water (representing light (SW) and heat (LW) leaving the bucket, then the total amount of eater (energy) remains the same and there is no gain, hence the Earth's overall average temperature remains the same. Cover some of the holes – explain that this represents adding more greenhouse gases (just a brief explanation as this is covered later), or removing ice/snow so less energy is reflected (albedo). Students observe water level increasing – relating to more energy, thus heat on Earth. 6./ Students complete and calculate 3.1.4. Energy budget. Begin with labelling the sheet with energy data provided. Students can then calculate (all energy in- all energy out) and link to a temperature rise. *Advanced sheet only for extension students (math strength)*	O 3.1.1. Students can explain that shortwave energy, in the form of light, radiates from the Sun, and is absorbed by Earth's surface. O 3.1.1. Students can explain that the cooler Earth surface radiates long wavelength energy in the form of heat. O 3.1.4. Students can link the temperature of the Earth's surface to the balance between incoming shortwave radiation (light) and outgoing long wave length radiation (heat) O 3.1.4. Students can complete an Energy Earth budget, and calculate NET energy gain, linking it to an increase of temperature

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 3.1. Students understand how energy moves into, and out of Earth, to produce an Energy budget (PE & B 5.2.a, PW 4.1.a, 5.1.a.)	O 3.1.5. Students investigate how the colour of the ground surface can affect the amount of energy absorbed (Albedo Effect)	O 3.1.5. Students work in groups to complete investigation O 3.1.5. Individually working online	O 3.1.5. Albedo Effect investigation (created) equipment: polystyrene cups and digital thermometers O 3.1.5. Feedbacks of ice and clouds. Interactive module. https://bit.ly/2E48FPn	1./ 3.1.5. Albedo Effect investigation: Students work in groups to test the temperature of various coloured surfaces outside. (Full Instructions on sheet). 2./ Follow up questions analyse the temperature difference. 3./ In a class discussion link the results to what might be the consequences of melting polar and ice areas 4./ 3.1.5. Feedbacks of ice and clouds module https://bit.ly/2E48FPn 45 mins. Links on OneNote	O 3.1.5. Students can conclude that darker surfaces absorb more energy from the Sun, and reflect less light, leading to an increase in the Earth's energy budget.
O 3.2. Students identify that some gases, called greenhouse gases, in the atmosphere can affect the energy balance (forcing agents) by absorbing heat, and producing the Greenhouse Effect. (PE & B 5.2.a, PW 4.1.a, 5.1.a, MW 3.2.a, 4.2.a, 5.2.a, 5.2.c. PE & B 3.2.b., 4.2.b., 5.2.a.) *[Optional: opportunity to cover gas tests. (MW 3.1.a., 4.1.a,)]*	O 3.2.1. Students describe the Greenhouse Effect as a natural process, that is necessary to allow life on Earth, and investigate the role that greenhouse gases play in the Earth's energy budget. O 3.2.2. Students identify carbon dioxide, methane, and water vapour as three of the major greenhouse gases. O 3.2.3. Students investigate whether carbon dioxide speeds up the transfer of thermal energy, and therefore acts as a greenhouse gas. *O 3.2.4. Students explore the relationships between ocean surface temperature and levels of atmospheric carbon dioxide and water vapour. (extension)*	O 3.2.1. Whole class discussion O 3.2.1. Individually working online O 3.2.2. Whole class demonstration O 3.2.3. Working in small groups for practical investigation	O 3.2.1. Greenhouse gases cards (found) https://go.nasa.gov/2sE14RE O 3.2.1. Greenhouse effect simulation games https://bit.ly/2PgPSkV https://bit.ly/2ei1ljy https://go.nasa.gov/2E5F8EP O 3.2.2. Molymods (small plastic) for demonstration O 3.2.3. NEED Greenhouse in a bottle investigation format sheet - and equipment listed (+ dry ice if available) (found) https://bit.ly/2y7Vk3b *O 3.2.4. Sources, sinks, and feedbacks interactive module https://bit.ly/2PhpF5T*	1./ Discuss greenhouse effect and greenhouse gases as a class. Use 3.2.1. greenhouse gases cards as an expert group 15 min research activity https://go.nasa.gov/2sE14RE 2./ Students use a 3.2.1. greenhouse gas simulation game on their devices – several suitable https://bit.ly/2PgPSkV https://bit.ly/2ei1ljy https://go.nasa.gov/2E5F8EP 3./ 3.2.2. Demonstration, using smaller set of molymods with longer connectors. Have CO_2, CH_4, N_2O, H_2O, O_2 and N_2 made. Show students how the CO_2, CH_4, N_2O, H_2O gases are able to flex around their bonds – link this to their ability to absorb and then release energy (LW). Show the O_2 and N_2 having little flexibility – and hence do not absorb and act as greenhouse gases. 4./ Practical investigation 3.2.3..Greenhouse in a bottle. Students set up two bottles to model Earth's atmospheric system, one with CO_2 added and one without. They will then follow instructions to record temperature at various time intervals, simulating day and night conditions. The question posed to the students is "What affect does adding carbon dioxide to the air have on the air's temperature during the day and during the night?". Students can work in groups to develop a conclusion, and then contribute to whole class discussion. *5./ 3.2.4. Sources, sinks, and feedbacks. https://bit.ly/2PhpF5T 45mins This is part of a module series. Module links will be included in students OneNote, as part of their self-paced learning. that is part of a series (extension)*	O 3.2.1. Students can explain the importance of the greenhouse effect in keeping the Earth at a temperature suitable for life, and that some gases, called greenhouse gases, in the atmosphere can affect that energy balance, by absorbing heat (and some light) O 3.2.2. Students can understand why some gases in the atmosphere, such as CO_2, CH_4 and H_2O, act as greenhouse gases, while others, such as N_2 and O_2, do not. O 3.2.3. Students can link the presence of more CO_2 in the atmosphere, to more energy being retained around Earth, and hence an overall increase in average temperature.

Macro Task: 4. Link the consequences of the increasing carbon dioxide gas in the atmosphere, to the effect on Earth's physical systems, leading to climate change.					
Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 4.1 Students understand that carbon dioxide concentration has increased rapidly in the atmosphere, and that carbon dioxide emissions, created from human activity, is the main reason for this increase (MW 3.2.a., 4.3.a, 5.3.a, NoS 3.1.b., 4.1.b., 3.2.a, 4.2.a., 5.1.a, 3.2.b, 4.2.b) *[Optional: opportunity for local scientist visits and/or studies (NoS 3.1.b, 4.1.b)]* ..	O 4.1.1. Students explore how carbon dioxide atmospheric concentration data can be collected, in both prehistoric times and recent times. O 4.1.2. Students graph atmospheric carbon dioxide concentration data from pre-industrial time and recent times. O 4.1.3. Students link the rapid increase of CO_2 concentrations in recent times to human activity, and refer back to possible sources of emissions from the carbon cycle activities.	O 4.1.1. Whole class activity. O 4.1.2. Individual graphing activity O 4.1.3. Individually working online O 4.1.3. Whole class, followed by class discussion.	O 4.1.1. Video clips of ice core collection https://bit.ly/2PiOezo https://bit.ly/2fzd1BQ https://bit.ly/2RwR1WX O 4.1.2. "How much CO_2?" worksheet (GZ) O 2.1.3. Carbon on Earth worksheet (GZ) O 2.2.1. Carbon cycle model (GZ) O 4.1.3. Interactions within the atmosphere digital module https://bit.ly/2BZkNyo O 4.1.3. "Thin Ice: The Inside story of climate Science" documentary	1./ Students watch 4.1.1. clips of scientists collecting ice cores from Antarctica to retrieve prehistoric atmospheric carbon dioxide data. https://bit.ly/2PiOezo and New Zealand Scientists collecting ice-core samples https://bit.ly/2fzd1BQ or https://bit.ly/2RwR1WX 2./ Students compare this to modern day collections of data from Mauna Loa. "the observatory has been collecting and monitoring data relating to atmospheric change since the 1950s. Dr John Barnes, the Station Chief for the observatory, describes the functions of the MLO, which provides valuable long-term and continuous recording of data" https://bit.ly/2C0NxH1 3./ 4.1.2. How much CO_2? .Students provided with data of CO_2 from the past 300+ years, of which they need to graph the past 60 years. Students can use information from previously completed 2.1.3. and 2.2.1 sheets to give explanation for where the excess CO_2 emissions have come from. Students can also research the dates of when combustion engine transportation became common, increase in coal burning power stations etc., and add to their graphs. 4./ Brief class discussion on reasons for fluctuations and rate of change past of CO_2 levels. 5./ 4.1.3. Interactions within the atmosphere digital module (on OneNote) 45mins - https://bit.ly/2BZkNyo 6./ 4.1.3 Thin Ice: The Inside story of climate Science documentary can be introduced at this stage, focussing on the collecting data, monitoring, and investigating climate change. – this will lead into the next segment of making evidence backed statements. https://thiniceclimate.org/ (email thiniceclimate@vuw.ac.nz. For free of charge streaming link.) Followed by cognitive tools activities on OneNote.	O 4.1.1. Students can observe that scientists use a range of methods to collect atmospheric CO_2 data, both from prehistoric and contemporary times. O 4.1.2. Students are able to correctly graph provided data on atmospheric carbon dioxide concentration O 4.1.3. Students can link human activity to the most recent rapid increase in CO_2 in the atmosphere.

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 4.2. Students will understand that climate change has impacted on Earth's Physical systems, resulting in global temperature rise, sea level rise, cryosphere melting, and increasing the frequency of extreme weather events (NoS 3.1.a, 4.1.a, 3.2.b., 4.2.b, 5.3.a., 5.3.b., PE & B 5.2.a.) *[Optional: opportunity to cover acid-base neutralisation and equations (MW 3.1.b., 4.1.b., 5.1.a.)]* *[Optional: opportunity to cover heat transfer and heat expansion. (PW 3.1.a., 4.1.a., 5.1.a., 4.3.a.)]*	O 4.2.1. Use collected evidence (data and graphs), and current models, to make evidence supported claims about the impacts of climate change O 4.2.2. Students investigate what effects sea and land ice have on sea level, when melted. *O 4.2.3. (Extension) Students investigate if acidification of water can increase the rate that shells (calcium carbonate) react, and disintegrate in water* *O 4.2.4. (Extension) Students investigate if increasing temperature causes the heat expansion of water.*	O 4.2.1. Small groups followed by class discussion O 4.2.1. Individually working online O 4.2.2. Small groups practical investigation O 4.2.2. Individually working online	O 4.2.1. Impacts on physical systems data activity (GZ - adapted) O 4.2.1. Constructing an argument: climate. Interactive module https://bit.ly/2PiHEsn https://bit.ly/2C0aF8o O 4.2.1. Earths' changing climates. Interactive module O 4.2.2. Land and Sea Ice investigation (GZ) equipment – beakers, ice cubes. O 4.2.2. NASA Future climate change simulation game https://go.nasa.gov/2sZIEqE	1./ In groups, Students will participate in 4.2.1. Physical impacts of climate change activity. They will work in small groups and are provided with 8 data cards, which show either observations or predictions of physical system change attributed to Climate change. Students need to analyse the information on each card, with 2/3 questions to answer. Then they will make an evidence backed statement on each card. 2./ Class discussion – on the requirements to be an evidence backed statement. Then followed by class contributions to each card (projected onto board. Students write down a summary for each card. 3./ This activity can be supported with 4.2.1. Constructing an argument: climate https://bit.ly/2PiHEsn , a 10 min module, and in a later lesson Earths' changing climates https://bit.ly/2C0aF8o, 45min module. Module links will be included in students OneNote, as part of their self-paced learning. 4./ 4.2.2. Set up 2 large beakers, with an inverted smaller beaker in each. Place 2 ice cubes around the bottom of Beaker A, and on Beaker B place the 2 ice cubes on top of the inverted beaker. Fill each with the same volume of water (but not above the inverted beaker – where the ice cubes sit in Beaker B). Place a heat source (lamp) close to each and record volume in each beaker every 2 minutes until all the ice melts. Student groups decide on a conclusion for the practical, and then discuss it as a class. (Only land ice and glaciers contribute to sea level rise, not sea ice – although melting does contribute to loss of habitat for polar animals) 5./ Students can play 4.2.2. Future climate change consequences on Earth simulation https://go.nasa.gov/2sZIEqE *6./ Additional practical investigations on acidification and heat expansion can be designed, by co-construction, and tested in groups. (Extension)*	O 4.2.1. Students are able to make evidence supported claims from observed and predicted data and models. O 4.2.1. Students can identify some of the consequences of climate change, including increasing temperature, changing precipitation patterns, sea level rise, and increasing frequency of extreme weather events. O 4.2.2. Students can conclude that only the melting of land ice, including the ice shelves in Antarctica, Greenland, and glaciers, contribute to sea level rise, NOT sea ice, such as that in the Arctic circle.

Macro Task: 5. Students investigate the effect that Climate change has on Human and Ecological Systems, and understand how Adaptation Strategies can be developed to manage current and future challenges.					
Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 5.1. Students will investigate how climate change may affect some species and global ecological systems, as well as some possible strategies that could be used to adapt to the changes created. (LW 3.2.a, 4.2.a., 3.3.b., 4.3.b, NoS 3.4.a, 4.4.a., 5.4.a, 3.4.b., 4.4.b.) *[Optional: opportunity to cover classification, MRS C GREN (LW 3.3.a, 4.3.a.,)]*	O 5.1.1. Students identify some species that will be impacted by climate change, and consider what adaption strategies could be used O 5.1.2. Students observe some animals in their 'habitats', and learn about how they might be affected by climate change O 5.1.3. Students play online interactive games showing how climate change may affect various species	O 5.1.1. Individual and paired activity O 5.1.2. Fieldtrip visit to the zoo as a group O 5.1.3. Individually working online	O 5.1.1. Our homes are changing (GZ) O 5.1.1. Arkive "climate change activity" (found) https://bit.ly/2QzAFM5 O 5.1.2. appropriate fieldtrip materials and support, RAMS forms O 5.1.3. Climate change ecosystems scenario interactive games https://go.nasa.gov/2K1RcGa https://bit.ly/2Nnwm4x	1./ Students begin with 5.1.1. Our homes are changing to match some select animal/plants, around the world, with their "stories" about how climate change may affect them. 2./ In groups, the students use sets of 5.1.1. Arkive Climate change activity https://bit.ly/2QzAFM5 "Students will play a game of pairs to match various species images with cards containing information on the main threat climate change poses to each particular species. In addition, students will consider what actions they can take to help reduce the impacts of climate change." Class discussion, and follow up cognitive tools to pair challenges with possible adaptation strategies. 3./ A 5.1.2. Zoo visit could be organised, with an educational facilitator, to observe some of the species, especially New Zealand species, and learn about their habitats, and how they may be affected by climate change – and what climate change adaptation is possible to reduce threats to the species. 4./ 5.1.3. Gamification: opportunity to play a selection of climate change online games, so students can interact with different scenarios Coral-bleaching interactive: https://go.nasa.gov/2K1RcGa Melting ice in Antarctica game: https://bit.ly/2Nnwm4x	O 5.1.1. Students can identify some effects to ecological systems, and the species within them, caused by climate change, both in the present, and most likely in the future. O 5.1.1. Students describe a number of adaptation strategies, which can be used, or developed, to assist species to adjust to the present, and future, climate change challenges.

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 5.2. Students will investigate how climate change may affect some New Zealand communities and ecological systems, as well as some possible strategies that could be used to adapt to the changes created. (LW 3.2.a, 4.2.a., 3.3.a, 4.3.a., 3.3.b., 4.3.b, NoS 3.4.a., 4.4.a., 3.4.b., 4.4.b., 5.4.a.) *[Optional: opportunity to cover ecology, and New Zealand habitats and species. (LW 3.2.a., 4.2.a., 3.2.a, 4.2.a., 3.3.a, 4.3.a., 3.3.b., 4.3.b)]*	O 5.2.1. Students research some case studies on vulnerable New Zealand species, and consider what adaptation strategies are being available to minimise the effect of climate change O 5.2.2. Students explore some possible effects of climate change on human communities, and consider what adaptation strategies are being available to minimise the effect of climate change	O 5.2.1. / 5.2.2. Students work in small groups on the adaptations case studies activity	O 5.2.1. NZ adaptation strategies card activity (GZ) O 5.2.1. Question maker dice (or make paper dice) Teacher resources for NZ adaptation https://bit.ly/2C9PZLy https://bit.ly/2Ojcyof https://bit.ly/2IP6NIY	1./ 5.2.1. Case study activity – students, either individually or in pairs, work through scenario cards of New Zealand species, and the problems they might face due to climate change. They are also provided with a range of 'adaptation solution' cards offering different adaptation strategies. The students discuss what solution might help that species, and provide a reason for why they have selected this card. Pairs then join, and in turn each justify to the other, their reasons for each. (Teacher resource to support activity: use DOC: Adapting to a changing climate. A proposed framework for the conservation of terrestrial native biodiversity in New Zealand https://bit.ly/2C9PZLy And DOC: Potential effects of climate change on New Zealand's terrestrial biodiversity and policy recommendations for mitigation, adaptation and research https://bit.ly/2Ojcyof) 2./ Students roll two 5.2.1. question dice (1 dice with what, when, why, where, how *and 1 dice (extension) with if, might, should, could, would*) to construct a question about a climate change scenario for a local ecosystem/species – and offer suggestions for how they might go about solving the problem. I.e. what…if…. Rising sea levels covered mangroves, that were important breeding grounds for some marine species – possible solution – plant more mangroves in areas where there are none. 3./ Students will investigate how climate change may affect human communities, (water scarcity, food production, health etc.) as well as some possible strategies, and technologies, that could be used to adapt to the changes created. Teacher resource: https://bit.ly/2IP6NIY Adapting to climate change in New Zealand: stocktake report. 5.2.2. This activity could involve mind-mapping, expert groups, research posters, role-playing, or videoed drama/skit. Students can be given the option for how they wish to present this LO.	O 5.2.1. Students can describe some New Zealand species affected by climate change, and identify possible adaptation strategies that can be planned and/or implemented to help them better cope with changes to their environments. O 5.2.2. Students can describe some New Zealand human communities affected by climate change, and identify possible adaptation strategies that can be planned and/or implemented to help them better cope with changes to their environments.

Macro Task: 6. Students investigate some Mitigation Strategies used to limit or control the factors contributing to Climate change, and assess how they can contribute, by reducing their own carbon footprint					
Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 6.1. Students understand how climate change mitigation strategies can be used to limit or control the factors contributing to Climate change (NoS 3.4.a., 4.4.a., 5.4.a., 3.3.b., 4.3.b.) [The political aspect of mitigation could be covered to a greater extent by the social studies curriculum, as a cross-curriculum component. including the goals of the Paris Climate Agreement, and the carbon trading program]	O 6.1.1. Students watch some case studies of climate change mitigation that governments and industries are implementing to help offset, or reduce, their carbon dioxide emissions	O 6.1.1. whole class activity	O 6.1.1. Mitigation case study short videos https://bit.ly/2PpMfJG	1./ The class watches a selection of 6.1.1. Mitigation case study short videos from businesses, industries, and governments, which are investing in carbon-offset programmes, such as forestation, alternative fuels, renewable energy, or landfill and fuel production gas capture. The reason and importance of their projects is discussed. 2./ Case studies (and links) of various projects of various mitigation projects can be analysed for positives and benefits (Thinking tools), as an OneNote collaborative activity. 3./ A 6.1.2. Field visit can be planned to a marae, iwi, or community group, which is involved in tree planting, or another mitigation project. During the visit, the students can hear about how that project contributes to mitigation. (future participation may be the basis for a student/s project work in the next task) 4./ 6.1.3. Mitigation strategy game (found) https://stanford.io/1yrb7nJ "Activity Goal: Students will be able to work in groups to create, analyse, and justify global mitigation plans in response to global warming. Students will learn about technologies currently available that can substantially cut carbon emissions. Students will individually analyse a standardized plan as the final performance assessment." This is a three-lesson task, where students move from different sized groups to whole class activity. 5./ 6.1.4. Using models to make predictions. Interactive module. 45mins. https://bit.ly/2zW7k8V	O 6.1.1. / 6.1.2. Students investigate, and contribute to, some mitigations actions that are being undertaken, both globally and locally, which reduce the factors contributing to climate change.
	O 6.1.2. Students visit a local group that is involved in climate change mitigation	O 6.1.2. Field trip for tree planting or restoration activity with iwi group, or enviro schools organisation	O 6.1.2. appropriate fieldtrip materials and support, RAMS forms		
	O 6.1.3. students work in groups to decide on appropriate mitigation strategies (at governmental level), and justify their decisions	O 6.1.3. Group activity	O 6.1.3. Pangea 'middle school' mitigation activity https://stanford.io/1yrb7nJ		
	O 6.1.4. Students explore how solar radiation, Earth's surface and oceans, and greenhouse gases interact to cause global warming. Students change variables to determine how much greenhouse gas emissions might need to fall to mitigate the temperature increase.	O 6.1.4. Individual digital activity	O 6.1.4. Using models to make predictions. Interactive module https://bit.ly/2zW7k8V		

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 6.2. Students understand that their own actions can contribute to reducing the factors increasing climate change, and consider mitigation options they might apply to their own carbon footprint. (NoS 3.4.a., 4.4.a., 5.4.a., 3.4.b., 4.4.b.)	O 6.2.1. Students participate in a group game to identify which of their own actions can reduce greenhouse gases (mitigation), and which increase greenhouse gases. O 6.2.2. Students calculate their own personal carbon footprint, and consider ways to reduce it.	O 6.2.1. Board game played in small groups O 6.2.1. class discussion O 6.2.2. individually working online with interactive	O 6.2.1. Save the climate game (found) https://bit.ly/2E5gRPo O 6.2.2. CO_2 reduction simulation https://bit.ly/2y9r7k0 O 6.2.2. Calculating carbon footprint interactive https://go.nasa.gov/2p3kjSl https://bit.ly/2k6yTqe	1./ 6.2.1. Save the climate game. (Materials printed out and played). Played in groups, students take turns to work through scenario cards, assign them to increasing or decreasing greenhouse gases, and then work through solutions and alternatives. All resources can be downloaded from https://bit.ly/2E5gRPo "Description from Game: This board game shows students which actions contribute to climate change and reduce greenhouse gases. In teams, students go through a set of cards and identify which actions they and their families do. If desired, print the cards on either green paper (reducing greenhouse gases) or red (contributing to climate change.) If you print the cards on one colour paper, the teams will have to decide themselves. After they put their actions on the board, they count how many cards increase versus reduce greenhouse gases. They then identify actions to change the behaviours that contribute to climate change to green actions 2./ Discussion Importance of reducing CO2 emissions, and link to 6.2.2. Momentum Simulation demonstration https://bit.ly/2y9r7k0 To show effects of reducing CO2 3./ 6.2.2..Gamification: online carbon offset game https://go.nasa.gov/2p3kjSl 4./ 6.2.2. Calculate your own carbon footprint, and consider options to reduce it. https://bit.ly/2k6yTqe	O 6.2.1. / 6.2.2. Students describe some daily actions, which create their carbon footprint, and identify small changes that can be made to reduce it.

Macro Task: 7. Students, with support, will design their own small group, or individual, climate change mitigation project, research, or initiative, which they will action and/or present to an audience.					
Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 7.1. Students design and action a small group, or individual, mitigation project (NoS 3.4.a., 4.4.a., 5.4.a., 3.4.b., 4.4.b., 3.3.b., 4.3.b., 5.2.a., 5.2.b., 5.2.c.)	O 7.1.1. Students select, and adapt, a suggested mitigation project, or plan their own with support. O 7.1.2. Students action their mitigation project, either individually, or in small groups	O 7.1.1. Small group, or individual planning O 7.1.2. Small group, or individual (may be outside school hours, which will require parental permission and supervision)	O 7.1.1. / 7.1.2. planning materials as requested by students or groups O 7.1.1. Project feedback rubric (GZ)	1./ This project, (7.1.1.) investigation or initiative will be used as the student's summative assessment for this unit. A rubric, which will be used for planning and feedback, will be co-constructed., during a session that allows students to contribute ideas about what is important for them, in a discursive activity The project is envisioned to take 2-3 weeks of class time to plan, and action. Many students may also decide to collaborate and action outside of class time. 2./ A selection of options are listed which a student, or small group of students, can select from. Alternatively, students may choose to plan, and research their own projects – links to possible sites will be provide. Students set up their collaboration page / OneNote, so they can continue with collaborative planning outside of school, and use as their on-going evidence, and reflection site. 3./ Some ideas that may be suggested to students: > Planning, documenting and reporting about energy use reduction in their own homes >Making a blog about local mitigation efforts, with interviews of the people involved >Making an energy reduction / carbon foot print reduction plan, with justification to present to the school Board of Trustees, and Principal >Join a local community group involved in a mitigation (tree planting etc.) initiative that you can volunteer with, and produce a report. >Suggest, and develop, a mitigation initiative that could be presented to a local businesses 4./ Time will be then given in class, with teacher facilitation, to help with actioning their plan (7.1.2.)	O 7.1.1. Students can co-construct a feedback and assessment rubric O 7.1.1. Students can select, adapt, create or plan a feasible mitigation project O 7.1.2. Students are able to action a feasible small mitigation project.

Meso	Micro	Organisational Frame	Focal Artefacts	Planned Interactions	Key Outcomes What do I Expect
O 7.2. Students present or publish their mitigation project (NoS 3.3.b., 4.3.b.)	O 7.2.1. Students present their projects at a parents evening at school O 7.2.2. Students complete an end of unit survey, reflecting on their learning, engagement and next steps.	O 7.2.1. Evening presentation with parents at school O 7.2.2. Individual online survey	O 7.2.1. presentation equipment, shared supper O 7.2.2. Digital survey created on FORMS.(GZ)	1./ Individual and group presentations (7.2.1.) are made at a Parents night. They may include multi-media, such as videos, slides. Presentation will form part of the assessment grade. 2./ Students can include samples of their work from the unit, and explain why mitigation is important, in the context of climate change. 3./ Students complete a 7.2.2. Digital end of unit survey. This gives them an opportunity to reflect on their learning, discuss which of the activities they found engaging and why, and what next steps they wish to take in their learning. Links to further reading can be provided.	O 7.2.1. Students are able to clearly present their mitigation projects, explaining their goal and outcome, and how the project has contributed towards climate change mitigation. O 7.2.2. Students can reflect on their learning and engagement in this climate change unit.

Notes about Unit

Digital resources/ focal artefacts listed in Unit Plan + Teacher slide presentation + Student Progress Tracker + links, are found:

http://gzscienceclassonline.weebly.com/climate-change.html

Focal artefacts not stated explicitly in the unit include the student's OneNote workbooks, containing the 'Progress Tracker' (appendix 1.), text, additional cognitive tools, literacy activities, and collaboration tasks. Many of the digital worksheets, links to simulation games, interactive modules, and supplemental instructions for group activities, will also be placed into the book. The OneNote book will also be used as a scientific notebook, and data collection site, for investigations.

Education Perfect is a purchased educational programme currently in use by the Science Faculty, but not essential for this unit. Teachers can pre-select 'assessments', that give students directed feedback for further tasks. Students are also able to self-select modules, as they work towards their Success Criteria (LOs). If this programme is available to students, then it will run concurrently with the LOs of the unit.

3. Justification

3.1. Learning Outcomes (LOs) were developed in this Unit Plan (LOs), with use of the Climate Change Content Knowledge identified in the previous Phase, and then modified to fit within L3-5 of the New Zealand Curriculum. Further to that, LOs for the Nature of Science, and Science skills, such as graphing, investigating, calculating, and using appropriate Science symbols and texts, have been intertwined, when suitable for the context (Ministry of Education, 2014). The LOs have been written as verbs, with actions that can be assessed (Kober, 2015), and these have then led onto a 'Progress Tracker', based on curriculum levels, to guide the students, and provide direct feedback for their progress. Ratnam-Lim, & Tan (2015) discussed effective feedback as being both a product, and a process, helping students on their journey of learning, rather than just as a final indicator of what they have achieved. The next stage was to curate, and create, a range of pedagogical strategies, justified to effectively support students to work towards the LOs (see 3.2.). This process of building the unit 'backwards', from what I wanted the students to achieve, can be considered learner-centred (Byrne, 2016), and ensures that the focus of the tasks remains orientated towards that purpose. Students are also able to see each task as more purposeful, and contributing towards a particular LO (Success Criteria). This Unit combines many different tasks and strategies for the learners to engage in, which can facilitate their understanding of climate change. While some of the tasks require, by their very nature, hands-on practical work, other tasks give the students the option of integrating components of digital work. Students can select whether they choose to record their work either digitally, or on paper, and there is flexibility for both individual, and/or shared work, for many tasks. Justifications for each major type of task are given below, in table form, for clarity.

3.2.

Type of Tool or strategy	Specific tasks	Justification
O Misconception and preconception tools O Concept Cartoons	O 1.1.1. Climate change "Cartoon Concepts" scenario card sets O 1.1.2. "scientist says" class slide set	When introducing climate change to students, a topic that involves a broad range of scientific disciplines (Versprille et al., 2017), it becomes apparent that many students, and teachers, arrive with pre-existing misconceptions (National Research Council, 2012). It will not suffice to just provide the correct

		'answers' to the learners and move on, rather the learners need to develop, or construct, their own knowledge (Kober, 2015). Cartoon Concepts, further developed by Keogh & Naylor (1999), are one such pedagogical tool that allows students, through discursive and reflective activity, to consider alternative views (Andrews, 2003). I have developed a set of Cartoon Concepts for this unit, with each card focussed around a question based on the science concepts of climate change, rather than visual cues. A further modification is the 'Scientist Says' prompters, based on researched statements, and these are designed to support the teacher when in discussion with the students. The Cartoon Concepts use a 'group' of characters in a discussion, with at least one having the scientifically correct understanding (Keogh & Naylor, 1999), and the students are then 'invited in' to the conversation, to put forward their ideas, some of which may be alternative concepts. This tool allows students to consider their own position that they hold on an idea, and with discussion, be able to justify any movement towards a new understanding. Pruneau et al. (2003) explain "In science, noting a conceptual change in students constitutes tangible proof that learning has occurred" (p. 5). Having used this tool previously at the start of other units, I found it engages the students, as well as provides 'interest points' for students to investigate further as we move through the content.
O Cognitive tools O Thinking tools O Flow charts O Concept maps O Organisation charts O Digital learning environment	O 1.2.1. Weather or Climate sorter activity O 1.2.1. Venn diagram O 1.3.3. Concept mapping O 2.2.4. readwritethink literacy tools O 3.2.1. Greenhouse gases cards (expert groups) O 5.2.1. Question maker dice O 1.3.2. Digital worksheet of climate features *O 1.3.3. Digital worksheet of*	Climate change can be a challenging topic for students, (and teachers), bringing in a multitude of interacting disciplines (Oversby, 2014). Cognitive Tools, often used in a student-centred environment, support students to seek information and then present it, as well as organise, integrate, and generate knowledge (Iiyoshi, Hannafin, & Wang, 2005). These tools encompass a wide variety of examples, both 'hands-on' and digital, to engage and facilitate specific cognitive activities (Jonassen, 2003). Concept Maps, one such example, allows the students to make connections (Castek & Dwyer, 2018) between the many varied interactions in the climate components, a complex concept with students requiring support to construct knowledge. Nesbit & Adesope (2006) suggest concept mapping can be more effective than text-

	climate features, and human influence (extension) O 2.2.2. Carbon cycle model O 2.1.3. Carbon on Earth worksheet	only based strategies, and useful in a broad range of contexts. Whitehead (2007) labels a similar group of strategies as literacy and thinking tools, and describes them as "construction tools for the mind" (p. 20). Venn diagrams and Question Makers are included within this category as learner-focussed tools. There is no reference in the unit plan to 'copying notes' as a learning strategy, with its limited use as a pedagogical tool (Lock, 1985). Students will still have access to text through their digital books, and class presentations, but it is expected that they will process the information using a combination of cognitive/thinking tools, to make worthwhile constructs.
O Investigations O Nature of Science skills O Inquiry O Observation O Data processing	O 1.2.2. OneNote digital weather diary O 3.1.5. Albedo Effect investigation O 3.2.3. NEED Greenhouse in a bottle investigation O 4.2.2. Land and Sea Ice investigation O 3.1.4. Earth's energy budget sheet O 4.1.2. "How much CO_2?" worksheet O 4.1.1. Scientists collecting data from ice cores O 4.2.1. Impacts on physical systems data activity O 4.2.1. "Thin Ice: The Inside story of climate Science" documentary	This group of strategies utilise the Nature of Science Strand AOs (Ministry of Education, 2014), and are especially applicable to 'Investigating and Communicating' in Science. They involve 'active learning', often physical activity, which Byrne (2016) links to engaging students while they are building strong mental models. Wassermann (2015) describes the building the skills of Scientific Inquiry and Investigation as a means to create problem solvers, especially important when tackling a looming issue like climate change. Developing the learners' ability to make a valid fact-based argument (Osborne & Young, 1998) will also be essential, given the likelihood that they will encounter misinformation through the media, and their social networks. Linking learning to fact-based evidence and information can reduce the students' overreaction to the sometimes-frightening headlines generated by climate change (Heffron & Valmond, 2011). Numeracy skills are included within this category, with further opportunity for cross-curricular connection with Mathematics. Providing students with contemporary, and historical, data, for further processing, provides links to real-world situations (Smith & Mader, 2017). Observation of data collection by scientists, such as the ice cores, and collecting data themselves (weather data), strengthens the students' connection to 'real' science.
O Physical Models O Demonstrations	O 2.1.2. Large plastic Molymod sets	Difficult concepts, such as linking wavelength to the amount of energy, and exploring why the molecular structure of the greenhouse gases allows it to

	O 3.1.1. Slinky O 3.1.4. Energy balance demonstration O 2.2.4. NEED "Carbon Cycle Simulation" card game	absorb heat energy, can be well above the curriculum level of the students (Ministry of Education, 2014), but are important ideas to underpin climate change mechanisms. The use of physical models, such as 'Slinkys' and 'Molymods' (molecular models), can be far more effective than memorisation of abstract, and unobservable, ideas (Versprille et al., 2017). Students are able to build, manipulate and use the models to construct their own explanations for the phenomena. I have also included activity 2.2.4 in this category, as the students are using themselves as carbon atoms moving around, although this activity could very well be substituted with Molymods to the same effect.
O Problem-based learning O Socio-scientific issues O Role-playing O Decision making O Scenario and strategies O Board Games	O 2.2.4. NEED "Carbon Cycle Simulation" card game O 5.1.1. Our homes are changing O 5.2.1. NZ adaptation strategies card activity O 5.1.1. Arkive "climate change activity" O 6.1.3. Pangea 'middle school' mitigation activity O 6.2.1. Save the climate game	Problem-Based Learning deals with real-world situations, where students make their own decisions to solve issues (Barrows & Tamblyn, 1980). This type of pedagogical tool has many applications within climate change, and can take the form of role-playing, scenario and strategy games. Nordby et al. (2016) stipulate that authenticity and challenge be provided in problem-based learning, so that it will be of benefit to the students' future careers and study. Another aspect of these activities is to allow learners to understand that there is a range of consequences, resulting from climate change, which will affect many communities. Further to that, there is also a range of different adaptation strategies, some more suitable than others. Many of these problem-based activities also integrate socio-scientific issues (Sadler, 2011), most having no definable solutions. Scientific principles can go some way towards helping the students understanding the underlying causes of climate change, but often 'ethical' decisions have to be made by the students, when faced with a choice. Jones et al. (2007) explains the importance of an educational context that allows learners to develop their ethical decision-making through "dialogue, practice, confirmation and modelling" (p. ii). These activities allow flexibility in learner choice, and an opportunity for justification of their decisions when arguing about which adaptation solution they would choose, and why. Students move from an egocentric viewpoint, towards a more ethical viewpoint.

<table>
<tr>
<td></td>
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<td>These pedagogical tools can be useful for teaching the ‘Participating and Contributing’ component of the Nature of Science AOs, where students need to consider issues and make decisions about actions, especially in regards to sustaining the environment (Ministry of Education, 2014).</td>
</tr>
<tr>
<td>O Gamification

O Interactive modules</td>
<td>O 3.2.1. NASA greenhouse gas simulation games
O 4.2.1. NASA Future climate change consequences simulation game
O 5.1.3. Climate change ecosystems scenario interactive games
O 6.2.2. Calculating carbon footprint interactive</td>
<td>Gamification uses games, mostly in a digital format, for learning (Nordby et al., 2016). It can be a useful motivational tool for students, while developing skills, often in the guise of fun and challenge. Simulation games might allow the learners to experience a safe real-world situation without the consequences, very applicable in a climate change context. Meya & Eisenack (2018) explain that gamification can help “develop individual beliefs about sustainable development by experiencing complex system dynamics that are not tangible in everyday life”. Peterson et al. (2018) recognises that gamification can “activate the complex cognitive processes” (p. 96), while the learners are engaged in play.
<table>
<tr><th colspan="2">Advantages</th><th colspan="2">Challenges</th></tr>
<tr><td>Gaming can yield positive learning outcomes.</td><td>Gaming can promote authentic learning.</td><td>Gaming can promote extrinsic motivation.</td><td>Gaming can cause overload and frustration.</td></tr>
<tr><td colspan="4">What pedagogy can do</td></tr>
<tr><td>Pedagogies ensure sound integration of video games into the instructional context.
Pedagogies promote complementary structured activities to maximise the gaming experience.</td><td>Pedagogies ensure exploration and manipulation of realistic scenarios.
Designers and practitioners ensure access to high quality digital games.</td><td>Practitioners focus students’ attention on essential elements of learning.
Pedagogies rely on simpler video games.</td><td>Pedagogies provide useful feedback to the learner.
Pedagogies match the learner profile with the gaming experience.</td></tr>
</table>
Figure 1. Pedagogical implications of gaming environments. Retrieved from Peterson et al., 2018, p.106.
I have included games from the Climatekids NASA site, as well as numerous other sites linked in the unit. An interactive series of modules; “What is the Future of Earth’s Climate?”, has been interspersed throughout the unit, although this could also be considered a ‘flipped learning’ activity, with many tasks in this unit fitting into multiple categories. There may be possible future cross-curricular links with the Technology Faculty, where students create their own games, with the new digital curriculum being introduced over the next few years.</td>
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O Field trips O Expert visits	O 5.1.2. Fieldtrip visit to the zoo as a group O 6.1.2. Field trip for tree planting or restoration activity with iwi, or community group	There are several suggested field trips within this unit plan, all of which involve connecting with experts, both at the Zoo and within the wider community. Expert visits can include coordinating with the Enviroschool facilitators, or scientists, involved with the field of climate change. This pedagogical tool of incorporating visits, and trips, and allowing the students to make real-world connections with those people 'doing' science, can be considered socio-constructivist, providing a "tangible awareness of climate change through local observation" (Pruneau et al., 2003, p. 4). This approach, when the students are able to collect data, and assist in climate change initiatives, can be very motivating for them. All field trips will need to be planned well in advance, with school administration and RAMS requirements. Funding for the trips will be required from the students, as per school policy. Individual, or group, field trips requested as part of the project phase, will need to be independently supervised by caregivers.
O Projects O Inquiry	O 7.1.1. Students select, and adapt, a suggested mitigation project, or plan their own with support. O 7.1.2. Students action their mitigation project, either individually, or in small groups O 7.2.1. Students present their projects at a parents evening at school	Designing, implementing and presenting Projects, incorporating inquiry-based learning, can help students construct their own knowledge when based on real-world experiences (Kober, 2015), as they involve themselves by actioning a positive change (Doyle, 2011). The process of presenting their completed projects to an audience (of parents) allows them to justify their choices, and the share the decisions they made in the process (Castek & Dwyer, 2018). All of the processes involved can be considered critical skills, and allow a student to engage in, and take ownership of, their own learning (Bransford et al., 2000). The projects are purposely positioned at the end of the unit, firstly for the intention of being utilised as the summative assessment, with the students helping to co-construct the rubric, used for feedback and final assessment. Secondly, students will have had the opportunity to cover some of the skills previously in the unit, such as investigative skills, evaluating data and sources, as well as, hopefully, constructing a solid scientific knowledge base around climate change.
O Digital tools and collaboration	OneNote digital climate change books and	While the use of digital technology by the students is discussed in more general terms throughout this paper, I will focus on 'flipped learning', and

O Flipped classrooms	collaboration pages O 7.2.2. Students complete an end of unit survey, reflecting on their learning, engagement and next steps.	digital collaboration, as specific tools. The planned unit on climate change covers a vast portion of the Science curriculum, and many of the 'hands-on' tasks will occupy an entire lesson. Students will need to take the responsibility for gathering, and processing, additional relevant information (Byrne, 2016), in the form of text, digital modules, and assessment programs such as Education Perfect, outside of the classroom. This Flipped-learning approach allows the time for more Innovative Pedagogies in class (Roach, 2014), and shifts the more traditional, but still important, literacy and vocabulary tasks to 'homework' (Byrne, 2016), with the distinction being lesson preparation, rather than revision. Flipped Learning has the advantage of offering asynchronous (Glenn, 2018), and self-pacing learning (Tullis & Benjamin, 2011), as students can be flexible about when, and where, they learn, as well as vary the time they remain on each concept, which encourages self-management (Peterson et al., 2018). Collaboration, using the OneNote tool, was the focus of a previous inquiry this year https://sites.google.com/view/sarah-gaze/home. Reflecting on my findings, I will modify the tools use for this unit, and include it as a self-selected method for collaboration, rather than a compulsory tool. This decision is consistent with most tasks provided, and allow the students to choose the environment they wish to work in. Collaboration takes place during many of the activities, with students sharing their ideas, and prompting each other with questions (Castek & Dwyer, 2018). Digital collaboration allows this sharing to continue outside of the classroom (Scott et al., 2014), and can include artefacts such as video, images, and links, to appropriate sites. This may be particularly valuable if students are collaborating in a project, where longer periods of sustained work, much greater than the 60mins in class, will be most likely required (Byrne, 2016). As well as allowing for more flexible collaboration, digital technology might help students "to learn new and more productive ways of using those tools for collaboration" (Peterson et al., 2018, p. 108).

3.3. The use of Digital Technology (DT) throughout the unit is assumed, with the current cohort of Secondary School students described as third-generation digital natives (Peterson et al., 2018), who have spent much of their teenage lives exposed to "cell phones, tablets, cloud-computing tools, and social networking" (p.94). However, it is important not to assume that this familiarity is transferable to DT used in class, and like any other new tool or skill, time will be required for the student to develop competency in its use. Long-term meta-analyses have shown that the use of ICT (DT) has improved students outcomes, when comparing an 'average' student (Tamim et al., 2011), but this improvement is almost negligible if the DT is only used as a form of class presentation, or simply a substitute for a traditional non-digital method (Peterson et al., 2018). This change in my own practice, from an 'additive pedagogy' to a 'disruptive pedagogy' (Hedberg & Freebody, 2007), moving from delivery of information (additive), to a noticeable pedagogical change (disruptive), has been discussed in detail in a previous phase. The transition was supported by using the SAMR Model (Substitution, Augmentation, Modification, and Redefinition) (Hamilton, Rosenberg & Akcaoglu, 2016), to determine when, and where, to use DT. However, there has been a recent shift in my approach in the use of DT, mainly brought about by trial in my own classes. The use of DT, or not, is now mostly determined by the students' preference, bringing in student agency. This is subtly different to SAMR, where it is usually the teacher deciding for the student, about when, and where, to make use of DT. This blended e-learning, or Hybrid Pedagogy (Hutchings & Quinney, 2015), discussed in phase 1, allows students to switch between face-to-face learning (f2f), which is immediate and responsive (Kist, 2015), and DT, with an emphasis on self-management, in both individual, and collaborative settings. One of my roles in hybrid pedagogy, aside from facilitating, is to ensure that resources, artefacts, and tasks, can be approached in a variety of forms, so students can move between DT and non-DT, as they feel best suits their needs. Peterson et al., (2018) explains that "new pedagogies are shaped around the notion of 'self-regulated learning': approaches that intend to develop people's ability to manage and progress learning without the direct instruction of a teacher." (p.38). Corno (2008) talks about the 'adaptive teacher', that makes on-the-go decisions about what pedagogies can be utilised to best support and challenge each learner, not only for an individual learner, but adjusted as each learner develops further.

3.4. The combined purpose of these pedagogical approaches have the same end goal, to enable the learners to address the climate change issue, both critically, and informed (Byrne, 2016), however, they can be approached in a variety of ways. The learner activity can be classified into three main organisational frames: whole-class or teacher-led, individual or self-managed, and interactive group work (Peterson et al., 2018).

		What makes students keep working?				
		Teacher instruction	**Self-managed**	**Group dynamics**		
What do students work on?	**Teacher choice**	Lecture	'Personalised'	Collaborative	**Time-based**	**When do we move on?**
	Co-constructed	Mastery-based	Blended	Discussion	**Continuous assessment**	
	Student choice	Scaffolded Inquiry	Independent Inquiry	Project-based	**Final product**	

Figure 2. Different approaches create different learning experiences Retrieved from Peterson et al., 2018, p.39.

Although many of tasks in the unit are clearly delineated into one of the three frames, the Learning Objectives themselves allow for the students to move between the frames, to best suit their individual needs and capabilities. For example, when approaching the carbon cycle model (2.2.2.), the class may start with teacher instruction, but some students may quickly move into independent work, using their OneNote or Education Perfect learning program to supplement the activity. Some students may decide that discursive small group work allows them to understand the activity better, while others may require more support from the teacher, or rely on assistance throughout the entire task. The placement of this unit, during the school year, may determine the extent of the teacher-led component, as students become acquainted with independent work habits. The Project task has been purposefully positioned as the culmination of the unit, once the students become more confident to work independently, both as individuals, and in small groups. The student's Project will constitute the Summative Assessment, with the initially co-constructed rubric used as a feedback tool during the process.

3.5. As a final consideration, and interwoven within the science pedagogies, are the ethics of care and guardianship (manaatikanga) (Jones et al., 2007). This can be modelled by the teacher's own passion for conservation, and sustainability, as well as initiating connections with community groups, iwi, and educational facilitators, such as the Enviroschools co-ordinators. Students need to understand that, as citizens, they also have a responsibility to contribute to the care of the Planet, and more specifically, their own local environment (Smith & Mader, 2017). The Values, and Key Competencies of the NZC (Ministry of Education, 2014), including community and participation, ecological sustainability, integrity, and support, frame the teaching of climate change. The Learning Objectives, taken as a whole, can be considered successfully obtained when the learner has been able to apply the knowledge they have constructed in meaningful ways; for reflecting, considering other cultures perspectives, solving problems (Kober, 2015), and identifying what role they can play in the world.

"If the "science" of pedagogy is in identifying the mechanisms and potential impacts of different approaches, the "art" is employing and combining pedagogies effectively to achieve the desired effect in context."
(Peterson et al., 2018, p. 12)

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5. Appendix

Unit Resources found at http://gzscienceclassonline.weebly.com/climate-change.html

Junior Science Climate Change – Progress Tracker

Look carefully at the statements below. Tick each level as it is reached, as we cover each part of the unit

Curriculum Levels					
Level 3		Level 4		Level 5	
I can participate in a "Cartoon Concepts" activity to share my prior knowledge about climate change	☐	I can contribute to a class discussion, which might help to identify my misconceptions about Climate Change	☐		
I can use a Venn diagram, to identify some differences between weather and climate, and some similarities.	☐	I can use the information on the Venn diagram to construct paragraphs, comparing and contrasting weather and climate	☐		
I can use a concept map to link several main ideas about climate and weather	☐	I can connect most of the terms about weather and climate together on a concept map.	☐		
I can collect weather data, and record it using a diary	☐	I can graph weather and climate data, and make a simple statement about the differences.	☐	I can compare my weather data to local climate averages, and make a conclusion about the differences between weather and climate	☐
I can identify, and label components in a climate system model	☐	I can identify some examples of interactions between components in the climate system.	☐	I can describe how human activity can influence some interactions between climate components (extension)	☐
I can locate carbon on the periodic table, and write the chemical symbol for it.	☐	I can use molymods to construct models of CO_2 and CH_4,	☐	I can write the formula and name of simple carbon compounds	☐
I can identify where different forms of carbon, and where they might be found on Earth.	☐	I can link the forms of carbon to the processes that formed them	☐		
I can define "carbon sources', 'carbon sinks' and 'carbon stores"	☐	I can label each carbon (store) reserviour on a carbon cycle model, and identify it as a source or sink	☐	I can identify carbon sources that are increased, or created, by human activity.	☐
				I can compare the rate of transfer of carbon between reserviours in the pre-industrial revolution period, and present day	☐
I can use 'Slinkys' to model energy traveling in waves.	☐	I can explain that short wavelengths (Light) contain more energy than long wavelengths (Heat)	☐	I can define the following terms: energy transformation, absorption, emitting, short wave radiation, long wave radiation	☐
		I can identify the sources, and forms of energy, that move around the Earth.	☐	I can explain how radiant energy moves around the Earth in its different forms	☐
I can observe a demonstration, and understand that energy in = energy out, when balanced on Earth.	☐	I can use data to create an input/output model of energy budget for the Earth.	☐	I can link the excess of energy, in the energy budget, to an increasing temperature on Earth	☐
		I can investigate how the colour of the ground surface can affect the amount of energy absorbed (Albedo Effect)	☐	I can conclude that the albedo effect causes a change in the radiation balance of the Earth.	☐
I can describe the Greenhouse Effect as a natural process, that is necessary to allow life on Earth	☐	I can describe how the Greenhouse Effect contributes to a 'warmer' Earth.	☐	I can compare Earth's temperature to other planets in our Solar System, that do not have an atmosphere	☐
I can identify carbon dioxide, methane, and water vapour as three of the major greenhouse gases.	☐	I can link carbon dioxide remaining much longer in the atmosphere than	☐	I can model the structure of the atmospheric gases, and link CO_2, CH_4, and H_2O to their ability to absorb more longwave (heat)	☐

		other greenhouse gases, to having a 'greater effect' as a greenhouse gas.		radiation, compared to other gases in the atmosphere that are not greenhouse gases	
				I can describe greenhouse gases as 'radiative forcing agents', and when they increase, so does the amount of energy held in Earth's system.	☐
I can investigate whether carbon dioxide speeds up the transfer of thermal energy	☐	I can write a clear conclusion, based on my investigation.	☐	I can identify independent, dependant and control variables in my investigation, and explain how I can make my investigation more reliable.	☐
I can explore how carbon dioxide concentration data can be collected, in both prehistoric times, and recent times.	☐	I can graph atmospheric carbon dioxide concentration data.	☐	I can link the rapid increase of CO_2 concentrations in recent times to human activity, and understand how we are able to distinguish between natural and human-made emissions	☐
I can answer questions, using information from data and graphs.	☐	I can use collected evidence to interpret data and graphs, and current models.	☐	I can use collected evidence (data and graphs), and current models, to make evidence supported claims about the impacts of climate change	☐
I can investigate what effects sea and land ice have on sea level, when melted.	☐	I can write a clear conclusion, based on my investigation.	☐	I can identify independent, dependant and control variables in my investigation, and explain how I can make my investigation more reliable.	☐
I can identify some species that will be impacted by climate change (Global and New Zealand)	☐	I can explain what impacts climate change, such as drought, and temperature increase might have on some species and communities	☐	I can consider what adaption strategies could be used to assist species impacted by climate change	☐
I can watch some case studies of climate change mitigation, and describe how they help reduce, carbon dioxide emissions,	☐	I can define mitigation as reducing or preventing carbon dioxide emissions, and understand its importance in reducing the effects of climate change	☐	I can understand that governments, businesses and community groups have developed policies to reduce (or off-set) their carbon dioxide emissions.	☐
		I can visit a local group that is involved in climate change mitigation	☐		
I can participate in a group game to identify which of my own actions can reduce greenhouse gases (mitigation), and which increase greenhouse gases.	☐	I can calculate my own personal carbon footprint.	☐	I can consider ways to reduce my own carbon footprint, and action them	☐
I can select a suggested mitigation project.	☐	I can adapt a suggested mitigation project	☐	I can plan my own mitigation project, with support	☐
I can action parts of my mitigation project, either individually, or in small groups	☐	I can action, and complete my mitigation project, either individually, or in small groups	☐	I can action my mitigation project, either individually, or in small groups, and explain how my actions have resulted in climate change mitigation.	☐
I can participate in a presentation of my project at a parents evening at school	☐	I can clearly present my project at a parents evening at school, and explain how my actions were linked to climate change mitigation	☐	I can clearly present of my project at a parents evening at school, showing that I have gathered relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.	☐
I can complete an end of unit survey.	☐	I can complete an end of unit survey, and reflect on my learning, and engagement.	☐	I can complete an end of unit survey, that reflects on my learning, and engagement, and also consider what next steps I might wish to take.	☐