Department of Education

GOVERNMENT OF WESTERN AUSTRALIA

CURRICULUM RESOURCE MODULE

Climate calculations

YEAR 7

THE S+EM LEARNING PROJECT

scitech

STAWA SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

Acknowledgements

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The STEM Learning Project

The aim of the STEM Learning Project is to generate students' interest, enjoyment and engagement with STEM (Science, Technology, Engineering and Mathematics) and to encourage their ongoing participation in STEM both at school and in subsequent careers. The curriculum resources will support teachers to implement and extend the Western Australian Curriculum across Kindergarten to Year 12 and develop the general capabilities.

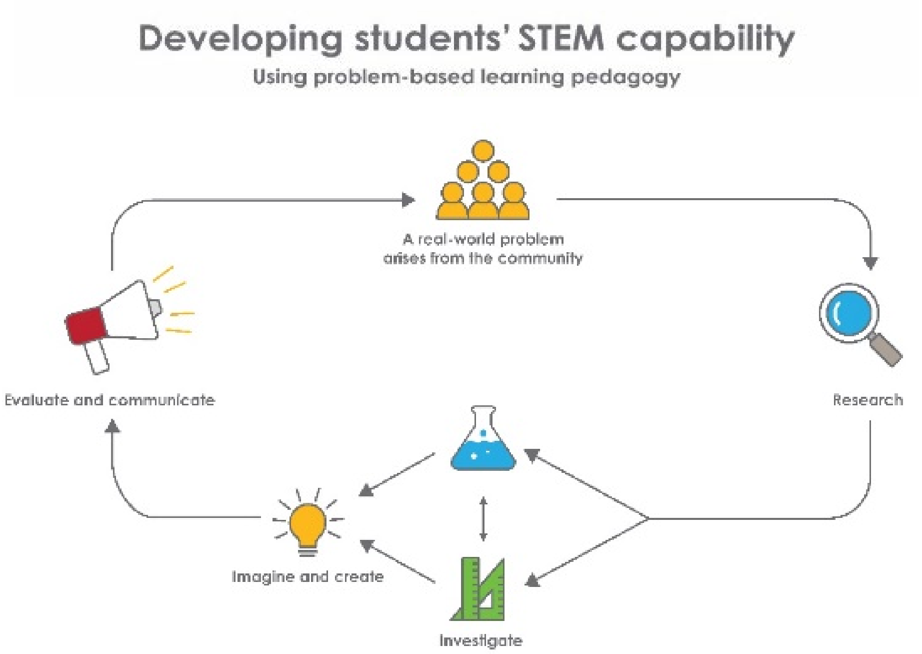
Why STEM?

A quality STEM education will develop the knowledge and intellectual skills to drive the innovation required to address global economic, social and environmental challenges.

STEM capability is the key to navigating the employment landscape changed by globalisation and digital disruption. Routine manual and cognitive jobs are in decline whilst non-routine cognitive jobs are growing strongly in Australia. Seventy-five per cent of the jobs in the emerging economy will require critical and creative thinking and problem-solving, supported by skills of collaboration, teamwork and literacy in mathematics, science and technology. This is what we call STEM capability. The vision is to respond to the challenges of today and tomorrow by preparing students for a world that requires multidisciplinary STEM thinking and capability.

The approach

STEM capabilities are developed when students are challenged to solve open-ended, real-world problems that engage students in the processes of the STEM disciplines.



STEM Consortium

Year 7 – Climate calculations

Overview

Climate change is already causing significant harm to both physical and biological systems in Australia, with considerable environmental and economic impacts for future generations.

Climate change is the result of the enhanced greenhouse effect caused by increased levels of greenhouse gases in the atmosphere which, in turn, result in more heat being trapped in the Earth's atmosphere.

Global concentrations of carbon dioxide and methane in the atmosphere have been rapidly growing over the past century and are now higher than at any other time (Bureau of Meteorology, 2017).

There is a time lag between the addition of emissions to the atmosphere and the climate's response; even if greenhouse gas concentrations are stabilised, associated impacts may continue for centuries (Intergovernmental Panel on Climate Change, 2013).

What is the context?

The likely impacts of climate change for Western Australia include increased risk of bushfire and drought, decreased average rainfall in south-west Western Australia; less freshwater; the need to accelerate infrastructure development, for example, additional water supply sources; increased risks to coastal settlements of coastal erosion, saltwater inundation and storm surge flooding; increased heat stress-related mortality and morbidity, particularly among the elderly; decreased agricultural production, potentially increasing the costs of both food and water and changing population distribution in regional areas; adverse impacts on recreation and tourism; increased risk of erosion in areas where low rainfall results in low biomass, especially where overgrazing occurs; and loss of terrestrial and marine biodiversity.

Adapting to our changing climate
(Department of Environment and Conservation, Western Australian Government, 2012)

Climate change presents risks to our communities, environment and economy which can be better managed and minimised with investment in good adaptation practice.

What is the problem?

How can technology help us respond to a changing environment?

How does this module support integration of the STEM disciplines?

The *Climate calculations* module connects students directly to the real-world problem of climate change. Students engage their science, technologies and mathematics capabilities to understand the nature of climate change and to develop approaches that communities might implement to adapt to climate change.

Science

Students investigate Earth's place in the solar system and how its distance from the Sun, the nature of its atmosphere, its rotation on its axis causing day and night, its orbiting and tilted axis causing seasonal changes all contribute to the amount of solar energy reaching Earth (ACSSU115).

Students develop science inquiry skills as they summarise data from their investigations and secondary sources, and use scientific understanding to identify relationships and communicate conclusions based on evidence (ACSIS124, ACSSIS129, ACSIS130, ACSIS132, ACSIS133). Through the analysis of a wide range of secondhand data, students develop an understanding of how a consensus view has emerged about climate change based on accumulated scientific evidence (ACSHE119, ACSHE120).

Technology

Students acquire climate change data from a range of digital sources (ACTDIP025), analyse the data and develop an understanding of the evidence about climate change. Students develop plans for innovative technologies to help communities adapt to climate change as they consider competing factors, including social, ethical and sustainability considerations, in the development of their technologies (ACTDEK029). Working collaboratively, students design, develop, review and communicate design ideas and apply given criteria to evaluate design processes and solutions (WATPPS41, WATPPS44, WATPPS45).

The *Design process guide* is included as a resource to help teachers understand the complete design process as developed in the Technologies curriculum.

Mathematics

Students explore distances between planets and the Sun and use decimals to create scaled representations of the solar system, which also involves rounding decimals to a number of decimal places (ACMNA154, ACMNA156). They investigate using index notation and represent the large distances between the Sun and planets in powers of ten (ACMNA149). When exploring various scale factors for distances in the solar system, students solve problems involving ratio (ACMNA173) and convert between length units, revising Year 6 content (ACMMG136). Students extract and analyse data from graphs in online datasets

(ACMNA180) to understand the variables impacting on climate change. Students calculate mean, median, mode and range for these data and interpret these statistics (ACMSP171, ACMSP172) and construct graphs to represent data (ACMSP170). Students identify issues associated with primary and secondary sources of climate change data (ACMSP169).

General capabilities

There are opportunities for the development of general capabilities and cross-curriculum priorities as students engage with *Climate calculations*. In this module, students:

- Develop critical and creative thinking skills as they research the problem and its context (*Activity 1*); investigate parameters impacting on the problem (*Activity 2*); imagine and develop solutions (*Activity 3*); and evaluate and communicate their solutions to an audience (*Activity 4*).
- Utilise creative thinking as they generate possible design solutions; and critical thinking, numeracy skills and ethical understanding as they choose between alternative ways to respond to climate change.
- Utilise personal and social capability as they develop socially cohesive and effective working teams; collaborate in generating solutions; adopt group roles; and reflect on their group work capabilities through peer evaluation.
- Utilise a range of literacies and information and communication technology (ICT) capabilities as they collate records of work completed throughout the module in a journal; represent and communicate their solutions to an audience using digital technologies in *Activity 4*.
- Communicate and, using evidence, justify their group's design to a local government councillor, community member or industry expert at the advocacy campaign.

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What are the pedagogical principles of the STEM learning modules?

The STEM Learning Project modules develop STEM capabilities by challenging students to solve real-world problems set in authentic contexts. The problems engage students in the STEM disciplines and provide opportunities for developing higher order thinking and reasoning, and the general capabilities of creativity, critical thinking, communication and collaboration.

The design of the modules is based on four pedagogical principles:

- Problem-based learning
  All modules are designed around students solving an open-ended, real-world problem. Learning is supported through a four-phase instructional model: research the problem and its context; investigate the parameters impacting on the problem; design and develop solutions to the problem; and evaluate and communicate solutions to an authentic audience.
- Developing higher order thinking
  Opportunities are created for higher order thinking and reasoning through questioning and discourse that elicits students' thinking, prompts and scaffolds explanations, and requires students to justify their claims. Opportunities for making reasoning visible through discourse are highlighted in the modules with the icon shown here.
  
- Collaborative learning
  This provides opportunities for students to develop teamwork and leadership skills, challenge each other's ideas, and co-construct explanations and solutions. Information that can support teachers with aspects of collaborative learning is included in the resource sheets.
- Reflective practice
  Recording observations, ideas and one's reflections on the learning experiences in some form of journal fosters deeper engagement and metacognitive awareness of what is being learnt. Information that can support teachers with journaling is included in the resource sheets.

These pedagogical principles can be explored further in the STEM Learning Project online professional learning modules located in Connect Resources.

Activity sequence and purpose

Activity 1

RESEARCH

Our place in space

Students research our place in the solar system and how that affects ambient temperatures on Earth.

Activity 2

INVESTIGATE

Climate change

Students analyse historical climate data to identify trends and extrapolate beyond recorded data to predict future changes to the Earth's climate.

Activity 3

IMAGINE & CREATE

Adapting to change

Students imagine, design and develop a technological solution to enable communities to adapt to climate changes.

Activity 4

EVALUATE & COMMUNICATE

Advocacy campaign

Students share their ideas through an advocacy campaign to raise awareness about a changing climate, including their data analysis, predictions and suggested solutions.

Background

Expected learning	Students will be able to: 1. Observe, measure and record data with accuracy. 2. Construct diagrams and tables to represent and describe observations, patterns or relationships in data. 3. Explain how distance from the Sun, rotation on its axis and a tilted axis determine the amount of solar energy reaching Earth. 4. Critically analyse data to draw conclusions about climate change and make predictions about future changes. 5. Locate, extract, analyse and interpret climate change data from online data sets. 6. Use index notation to represent the very large distances in the solar system. 7. Use ratios, convert between common units of length and multiply and divide decimals when calculating the scale of the solar system. 8. Describe data sets using median, mean and range and create dot plots to represent trends in data. 9. Imagine, design, develop and evaluate proposed solutions that will assist communities to adapt to climate change. 10. Address competing social, ethical and sustainability considerations when designing products or services. 11. Develop, document and communicate solutions using appropriate technical terms and representations.
Vocabulary	This module uses subject-specific terminology. The following vocabulary list contains other terms that need to be understood, either before the module commences or developed as they are used. analysis, astronomical units (AU), carbon, climate, climate change, cluster sample, conclusion, constants, control, dependent variable, dioxide, enhanced greenhouse effect, emissions, experiment, extrapolate, fossil frequency table, fuels, futures thinking, global average temperature, global warming, greenhouse effect, greenhouse gas, hypothesis, independent variable, law, mean, median, methane, mitigation, mode, normal distribution, population, probability, question, random sampling, range, reliability,

	renewable energy, sea-level rise, seasons, theory, weather, validity, variable, variance.
Timing	There is no prescribed duration for this module. The module is designed to be flexible enough for teachers to adapt. Activities do not equate to lessons; one activity may require more than one lesson to implement.
Consumable materials	A *Materials list* is provided for this module. The list outlines materials outside of normal classroom equipment that will be needed to complete the activities.
Safety notes	There are potential hazards inherent in these activities and with the equipment being used, and a plan to mitigate any risks will be required. Potential hazards specific to this module include but are not limited to: • Possible exposure to cyber bullying, privacy violations and uninvited solicitations when using the internet.
Enterprise skills	The *Climate calculations* module focuses on higher order skills with significant emphasis on expected learning from the general capabilities and consideration of what are considered to be enterprise skills. Enterprise skills include problem-solving, communication skills, digital literacy, teamwork, financial literacy, creativity, critical thinking and presentation skills. Further background is available from the Foundation for Young Australians in the *New Work Order* six-report series at www.fya.org.au/our-research-2/#series. Higher order thinking and reasoning can be encouraged by asking open questions and using higher order questions. Consider the following question stems to raise the level of questioning from Bloom's Taxonomy: Remember / knowledge: What is…? How would you show…? Where did you…? Which one…? Understand / comprehend: How would you explain…? How are these alike? Different? What is the pattern in the graph/table?

		Which, if any, does not belong?
	Apply / application	Predict what would happen if…? Why does … work? Using what you have learnt, how could you…?
	Analyse / analysis	What could have caused…? What are the positive and interesting…? Explain why it is not possible for…? How would you order…? How can you use your data in your conclusion about…?
	Evaluate	How well does the prototype meet the design criteria? How would you improve…?
	Create / synthesise	How could you show the relationships between…? How would you design an X to do Y?
Assessment	The STEM modules have been developed to provide students with learning experiences to solve authentic real-world problems using science, technology, engineering and mathematics capabilities. While working through the module, the following assessment opportunities will arise: • Anecdotal notes of observations as students work collaboratively • Data from mathematics investigations • Activity records from the science investigation • Student portfolios documenting their design process • Reflective journal entries • Self and peer evaluations. *Links to the Western Australian Curriculum* indicates the expected learning students will engage in as they work through the module. Evidence of learning from journaling, presentations and anecdotal notes from this module can contribute towards the larger body of evidence gathered throughout a teaching period and can be used to make on-balance judgements about the quality of learning demonstrated by the students in the science, technologies and mathematics	

	learning areas. Students can further develop the general capabilities of Information and communication technology (ICT) capability, Critical and creative thinking, and Personal and social capability. Continuums for these are included in the *General capabilities continuums* but are not intended to be for assessment purposes.

Activity 1: Our place in space

Activity focus

Students research our place in the solar system and how that affects ambient temperatures on Earth.

Background information

The Sun is a source of energy for the planets in the solar system. The Sun generates energy from nuclear fusion. Under the high pressure and temperature in the Sun's core, hydrogen nuclei fuse to form one helium atom. During the fusion process, radiant energy is released. The majority of solar energy is emitted in the form of light and heat in the visible and infrared regions of the electromagnetic spectrum. Earth's atmosphere acts as an insulation that shields its surface from the most damaging of Sun's rays. Temperatures in the extreme outer layers of the atmosphere called the Thermosphere (90 km to 500-1000 km above the Earth) can reach 1500 degrees Celsius. For more information see the link to *Earth's Atmosphere: Composition, Climate & Weather* in the *Digital resources* section.

The rays of solar energy spread out as they travel away from the Sun so that the further away from the Sun the lower the intensity of solar radiation. The rays also lose energy the further they travel. Consequently, the planets that are further from the Sun receive less energy and are colder than planets close to the Sun.

Gravity

Earth completes a rotation on its axis every 24 hours. The portion of Earth that faces the Sun at any given time is exposed to its light, which results in daytime (light). Conversely, the section which is not facing the Sun is experiencing night (dark).

The Moon

More solar energy reaches Australia in our summer than in our winter because the Earth is tilted on its rotational axis. The axis of the Earth is tilted 23.5^0 relative to the plane of Earth's orbit around the Sun. Because of this tilt, the southern hemisphere faces more directly towards the Sun and receives more solar radiation than in winter when the southern hemisphere faces less directly towards the Sun.

Instructional procedures	This activity involves separating the students into small groups. Students will continue to work in these groups throughout the module and group dynamics should be considered when dividing the class. To facilitate cooperative learning, group members can be assigned a role. These roles can be changed to give students experience in each role. For further information see *Teacher resource sheet 1.1: Cooperative learning - Roles*. Ensure students are familiar with effective online research skills and cyber safety. Optional: Choose an online collaborative tool that students are familiar with and create a template to guide student research. Online tools that can facilitate a collaborative research project include *Connect* or *Microsoft Office 365* applications such as: • *OneNote* • *Sway* • *PowerPoint* • *Word* *Google Earth* can be used as an additional tool when working through the activities to: • Measure distances • Explore the Moon and Mars • Map and compare datasets • Layer images over maps. For useful tips, see *Ten Ways to Use Google Earth in Your Classroom – It's Not Just for Social Studies* in the *Digital resources* section.
Expected learning	Students will be able to: 1. Observe, measure and record data with accuracy (Science). 2. Pose clarifying questions and make predictions about scientific investigations (Science). 3. Construct diagrams, tables and graphs to represent and describe observations, patterns or relationships in data (Science and Mathematics). 4. Use index notation to represent very large distances in the solar system (Mathematics). 5. Use ratio, convert between common length units and multiply and divide decimals to explore and create a scaled representation of the solar system (Mathematics).

	6. Explain how Earth's place in the solar system, its distance from the Sun, its rotation on its axis causing day and night, its orbiting and tilted axis causing seasonal changes all contribute to the amount of solar energy reaching Earth (Science).
Equipment required	**For the students**: Graph paper, cardboard or plywood, masking tape, torch, markers (one set per group) Sports ball (eg basketball) (one per group) Blank paper, pencil and clipboard (one set per group) Digital devices (iPad/laptop) *Student activity sheet 1.4: Solar system to scale*.
Preparation	Gather the equipment needed for the activities. Ensure students have access to the resource sheet.
Activity parts	**Part 1: What is climate change?** Engage students in a brainstorming activity to activate and document their prior knowledge about climate change. A placemat activity with groups of four students will allow each student to record their ideas in a section of the placemat. Once complete, conduct a gallery walk around the placemats so that the class can view the full range of ideas. See *Teacher resource sheet 1.3: Cooperative learning - Placemat*. Collate the main themes (eg causes of climate change, nature of change, consequences of change) from the placemat activity and introduce the problem of *how can technology help us respond to a changing environment?*
	Part 2: The Solar System Explain to students that to understand climate change, it is helpful to consider the relationship between the Sun and the planets within the solar system. Reinforce that the planets vary in size and are in orbits of varying distance from the Sun.

Remind students that the Earth and other planets are entirely dependent on the energy from the Sun for light and heat.

This activity helps demonstrate that as something moves farther from a light source, the less energy it receives from the light source.

In their groups, students attach a sheet of graph paper to a piece of cardboard or plywood with the masking tape. They hold the board perpendicular to the floor and shine a torch directly onto the graph paper from the side, about 60 cm away. Ensure students hold the torch parallel to the floor and perpendicular to the paper.

Ask them to trace the outline of the torch's beam on the graph paper.

Students double the distance from the torch to the paper.

Ask:

- Does the area of the beam on the paper increase or decrease?

Encourage students to try several distances both closer and farther from the paper.

Engage students in a discussion by asking:

- What happens to the size of the beam?
- What happens to the intensity (brightness) of the light as the torch is moved closer to and further away from the graph paper?
- How would you describe the relationship between the distance the torch is from the paper and the number of squares its light covers on the paper?
- How would you describe the relationship between the distance the torch is from the paper and the intensity (brightness) of the light

Relate the discussion to the distances from the Sun shown in *Student activity sheet 1.4: Solar system to scale*. Advise students they will use the same sheet for further activities.

This is an opportunity to introduce the use of scientific notation (index notation for powers of ten) to represent very large numbers. Space is included on the resource sheet to accommodate this activity.

It is helpful to introduce index notation in a way that enables students to understand the meaning of the base as denoting an 'action' as distinct from a numeral representing a quantity. For example, start from the unit 'one' and explain that the 'base' tells you the kind of multiplicative action that will be applied to the unit and the 'index' or 'power' tells you how many replications of that action to carry out.

So for 2^3, the action is 'multiplication by 2' and the number of replications of that action is '3'. Remembering that the starting point is always the unit '1', this translates to 1 x 2 x 2 x 2 = 8.

Note the importance of including the multiplicative origin of '1' when introducing this notation– it enables students to understand why 2^1 must equal 2 and 2^0 must equal 1, both of which can be confusing when students are introduced to index notation. Teaching it as meaning just 2 x 2 x 2 can imply a zero starting point for students who are still thinking additively. By including the unit as the starting point, students can follow the same reasoning and can make more sense of the process and the result, for example:

For 2^1 the action is 'multiplication by 2' and the number of replications of that action is '1', so 1 x 2 = 2.

For 2^0 the action is still 'multiplication by 2' but the number of replications of that action is '0', so 1 = 1 (ie 0 actions of x2 so the result remains '1').

Introduce powers of 10 in the same way and explore the relationship between 10^0, 10^1, 10^2, 10^3 etc and the place value system so they become fluent in rewriting the powers of 10 in index notation and connecting this to the quantities and the number of whole number places. For example:

10^6 = 1x10x10x10x10x10x10 = 1 000 000 - 6 zeros in 1 million

Extend to writing numbers like 3000, as 3 x 10^3, and 3500 as 35 x 10^2 and then 3.5 x 10^3.

Challenge students to rewrite the distances of the planets from the Sun in scientific notation, using decimals and whole numbers, and exploring variations. Introduce the alternative form they will notice when using their calculators with very large numbers (eg 3.5e+6 which means 3.5 x 10^6 or 3 500 000).

Assist students to recognise the decimal relationship in the number of places and the convention in scientific notation that the number is rewritten as a decimal making the left-hand digit as a unit with the index or power showing the total number of places after the decimal point. For example:

3 971 200 would become 3.971200 so 6 decimal places in all, therefore it's value can be represented as:

3.9712×10^6 or 3.9712e+6 –

Students can use multiplication to check they have the correct index notation for the distances. For example:

$3.9712 \times 10^6 = 3.9712 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 3\ 971\ 200$

Explain to students that this representation is typically used to shorten the length of very large numerals. Where appropriate numbers can sometimes be rounded to make the numerals even shorter in length, such as $7 214 634 412 000 could be written as $7.214634412 x 10^{12}$ or rounded to approximately $7 x 10^{12}$ without greatly affecting the original quantity of just over 7 trillion dollars.

Assist students to become familiar with using scientific notation to re-write very large numerals during this activity. In later years students will learn that negative powers of 10 can be used to represent extremely small numbers.

Ask students to use the distances in *Student activity sheet 1.4: Solar system to scale* to predict which planets receive more solar heat and light than Earth and which receive less.

Students work collaboratively in their groups to research and document information about the planets in our solar system. Allocate a different planet to each group.

Ask students to focus on:

- Temperature
- Atmosphere
- Length of day and year
- Any other features of interest.

Using a jigsaw activity, groups become experts on their assigned planet (see *Teacher resource sheet 1.3: Cooperative learning - Jigsaw*). The information they create will be used by the rest of the class so it must be accurate. If the class focusses on the eight major planets, a jigsaw will work with home groups of four students and eight expert groups, each researching two of the planets.

When the home groups have collated and documented the findings of the experts, discuss the main findings with the class:

- How are the first four planets different from the four outer planets? Why are they different?
- How does the temperature of planets vary with distance from the Sun? Why does it change?
- How does the atmosphere of a planet affect its ground level temperature?
- Why is Earth considered to be in the 'Goldilocks' position?

Draw out from students that the temperature the Earth receives from the Sun above our atmosphere can be as high as 1500°C, and varies hugely between day and night.

Ask students to consider:

- How does the Earth's atmosphere affect the surface temperature?
- What effect could the solar rays have on life on Earth if the atmosphere did not moderate the surface temperatures?
- What are the implications for temperatures on Earth of changing the composition of the atmosphere?
- How might this connect to climate change?

Part 3: Creating a scale model

Explain to students they will be creating a scale model of the solar system to display their findings of the planets.

Scaling the solar system based on the size of familiar objects can help students visualise the dimensions of the solar system and provide an opportunity to explore ratio relationships associated with scale.

Ask students:

- What if the Sun were the size of a basketball (eg about 25 cm in diameter), how far would it be from the Sun to Pluto?

Using a calculator and *Student activity sheet 1.4: Solar system to scale*, assist students to work through a series of calculations to determine an approximate scale factor for the relative size and distance from the Sun of each of the planets to scale, if the Sun was approximately the size of a basketball.

Ask stimulus questions such as:

- Could we fit the scale model within the classroom?
- Could we fit the scale model on the school oval?
- How big would the Earth need to be?

- How far away would Pluto need to be?

Students will need to be carefully guided through this process by the teacher. They need to understand that division is used to determine the scale relationship (the scale factor), and that the same units must be used.

Assist students to round numbers to fewer decimal places to simplify some of the measurements and the scale factor, without greatly affecting the scaled-down lengths.

It is suggested the following process is worked through with the class, helping them to make sense of each step:

- Convert scaled diameter in centimetres to kilometres (inverse of converting kilometres to centimetres).
- Divide the diameter of the Sun by the proposed scaled diameter in kilometres to determine the 'scale factor'.
- Divide by the 'scale factor' to determine the scaled sizes and distances for the planets.

(Note: many Year 7 students appear to understand the inverse relationship between multiplication and division, but can only operate effectively when small numbers are involved – careful teaching is required in this part.)

Return to the stimulus questions and the results of the calculations to recognise that the distance from the Sun to Pluto at the given scale would be over one kilometre, and the Earth would only be about 2 mm in diameter, which means trying to make a complete model using this scale would not be possible.

Challenge students in their groups to try and determine a 'scale factor' that would enable a scale model of just the Sun and the inner planets (ie Mercury, Venus, Earth and Mars) that would fit along one wall in the classroom.

This should provide an opportunity to practise division and multiplication of very large and very small numbers, and conversion between kilometres, metres, centimetres and millimetres and involve decimals. Students will likely need to interpret scientific notation on their calculators during this process. Teacher's input should be provided as needed.

Depending on the results of their calculations, an appropriate scale factor can be chosen and the scaled distances physically represented along one wall and showing the size of the Sun and the four planets, which will be tiny. The sun will be a bit less than 3 mm in diameter and the Earth barely a pencilled dot when the distance from the Sun to Mars is about 4.5 metres, using a scale factor rounded to 5e+10 = 5×10^{10} = 50 000 000 000.

The information collected in *Part 2* about the inner planets can be displayed next to the same planets on the scaled model.

Following the construction of the model, a tool such as *Build a Solar System* can be used to test the final calculations based on their scaled diameter for the Sun (see *Digital resources)*. Students could use the tool to try out other sizes for the Sun and consider the relationships involved. The input for this tool should be in millimetres. Note: for students to understand how such a tool is constructed it is important for them to carry out the calculations for themselves before introducing the tool.

Optional:

Students can predict the relative distances between planets on a long strip of paper, and then determine the relative distances using fractions. More information on this can be found on NASA's Solar System Scroll webpage, see *Digital resources*.

Part 4: Day and night

Provide students with a ball and a torch to investigate how the Earth's rotation on its axis is connected to day and night.

Students attach a cut-out map of Australia to one side of the ball to track its rotation. In their groups, students take a video or photos on a digital device and use an editing function such as *Markup* (or other photo editing software) to explain how rotation causes day and night on Earth.

Discuss students' observations by asking:

- What did you observe?
- What causes us to experience night?
- How does this explain variations in day and night temperatures?
- Why is it that differences between night and day temperatures are much greater inland than on the coast?
- What are the differences in night and day temperature in the outer layers of the atmosphere?

	Encourage students to research for themselves the answers to the questions.
	Part 5: Seasons Students work in groups to research how the seasons occur. Encourage them to review NASA's *What causes the seasons?* webpage (see *Digital resources*). Ask students to construct a digital representation to show what causes the seasons in Australia in the southern hemisphere. Provide an opportunity for each group to display and explain their representations. Challenge students to describe how their representations help explain the difference in summer and winter temperatures and how this varies depending on the distance from the equator.
?	**Part 6: Reflection and journaling** Encourage students to reflect on their learning and consider: • How does Earth's distance from the Sun affect temperature? • What contributes to Earth's temperature range? • How do the rotation of Earth on its axis and its revolutions around the Sun influence ambient temperatures in different parts of the Earth? • What is the importance of the atmosphere for Earth and how is this different for other planets?
Resource sheets	*Teacher resource sheet 1.1: Cooperative learning - Roles* *Teacher resource sheet 1.2: Cooperative Learning - Think, Pair, Share* *Teacher resource sheet 1.3: Cooperative learning - Jigsaw* *Student activity sheet 1.4: Solar system to scale*
Digital resources	Lunar Phases Interactive (McGraw-Hill Education, Unknown) *http://highered.mheducation.com/sites/007299181x/student_view0/chapter2/seasons_interactive.html* *Please note this an Adobe Shockwavew Flash file which may require you to change your browser settings. The direct link is:* *https://highered.mheducation.com/sites/dl/free/007248262*

	1/78778/Lunar_Nav.swf
	Ten Ways to Use Google Earth in Your Classroom – It's Not Just for Social Studies (Richard Byrne, Practical Ed Tech, 2019) practicaledtech.com/2019/05/20/ten-ways-to-use-google-earth-in-your-classroom-its-not-just-for-social-studies/
	Planets data table (Windows to the Universe, 2008) www.windows2universe.org/our_solar_system/planets_table.html
	Solar System Scroll (NASA, Jet Propulsion Technology, n.d.) www.jpl.nasa.gov/edu/teach/activity/solar-system-scroll/
	What causes the seasons? (NASA, Space Place, n.d.) spaceplace.nasa.gov/seasons/en/
	Earth's Atmosphere: Composition, Climate & Weather (Time Sharp, Space.com, 2017) www.space.com/17683-earth-atmosphere.html
	Build a Solar System (Exploratorium, n.d.) exploratorium.edu/ronh/solar_system/
	Google Earth https://www.google.com/earth/

Activity 2: Climate change

Activity focus

Students analyse historical climate data to identify trends and extrapolate beyond recorded data to predict future changes to the Earth's climate.

Background information

Human activities such as burning fossil fuels and agriculture are a major source of greenhouse gas emissions. If these emissions continue to increase over the next 50 years, levels of carbon dioxide concentration could triple (Lüthi, D., et al., 2008).

Human population growth combined with industrialisation has been a major driver of increased greenhouse gas emissions. Carbon emissions result from many activities that help us work, travel, grow crops and relax, and cutting emissions requires making difficult choices that will inevitably have significant consequences for large groups of people.

The greenhouse effect

The greenhouse effect describes the way the atmosphere acts as a blanket, keeping the Earth warm enough for us to live on while preventing the most dangerous of the Sun's rays to penetrate to the surface. With more greenhouse gases such as carbon dioxide and methane in the atmosphere, less of the heat that has been absorbed by the Earth can escape back into space, thereby increasing the temperature around the Earth and causing global warming.

Global warming

Global warming is the general increase in the Earth's average temperature caused by greenhouse gases trapping more solar heat in the atmosphere. Global warming is causing Earth's climate to change.

Climate change

Climate change refers to general changes in climate patterns, including temperature, precipitation, winds and other factors. Burning fossil fuels release carbon dioxide (CO_2) into the atmosphere, which heats the atmosphere. This causes changes in the long-term climate. In Australia, it may mean hotter and drier conditions and increases in extreme weather events like storms, floods and bushfires. Climate is also influenced by natural processes, such as changes in the Sun's radiation, volcanic activity or internal variability in the climate system, or due to human influences such as changes in land use.

Weather

Weather is the day-to-day changes in temperature, precipitation, wind and other factors.

Weather and climate form a complex system affected by the ever-changing conditions of the atmosphere, oceans, glaciers and land. The climate of a specific place is determined by the average weather conditions and statistics over a long period. Climate change is a statistical phenomenon, the effects of which are seen in the world around us.

Climate change impacts on Western Australia include:

Temperature

Since 1910, annual-average temperatures have increased by 0.9°C. Since 1950, most of Western Australia has experienced an increase of 0.1°C to 0.2°C per decade (Bureau of Meteorology (BoM)).

Rainfall

Between 1950 and 2011, rainfall has increased in the north-east of the State but decreased in the south-west, with the largest decrease in the Bunbury to Walpole region, falling by up to 50 millimetres each decade (BoM).

Sea level rise

Sea levels recorded at Hillarys indicate an increase of 9mm each year (BoM).

Seasons

Studies of weather data over long periods have revealed seasonal changes in weather patterns over the year. With European settlement, the European four-season model has been used to describe seasonal changes; however, Indigenous Australians have developed models that better fit with the Australian context. Traditional Indigenous knowledge regarding seasonal changes in the weather and plant and animal activity can be found on the BoM's Indigenous Weather Knowledge webpage (see *Digital resources*).

	Extrapolate Scientific predictions are based on existing data, often by extrapolating beyond the existing range of data to estimate the value of a variable. **Futures thinking** Strategic thinking that uses existing knowledge and proposes scenarios for probable, possible and preferred futures. For example, making well-informed predictions or extrapolating using current economic, environmental, social and technological trends; using divergent thinking (‘What if …’ explorations) about a given futures scenario; hypothesis; or systems-driven thinking.
Instructional procedures	This activity provides rich opportunities for students to explore online climate change data sets and conduct their analyses of the relationships between variables and trends within the data. Statistical capability has become increasingly important as society relies on information and evidence throughout industry, government and education. In this activity, students plan their data investigation through the interaction of the questions: • What do we want to find out about? • What data can we get? • How do we get the data? • What does the data show and mean? This activity also provides an opportunity to develop an understanding of the need for good public reporting and careful reading of the data and conclusions reported in the media. The tasks are best conducted as small group work with whole class sharing through a student planned symposium. The symposium will provide an opportunity for students to explain and justify choices made about analyses and interpretations. Encourage students to probe and prompt each other to justify all claims made.
Expected learning	Students will be able to: 1. Locate, extract, analyse and interpret data from online climate change data sets (Mathematics and Science). 2. Represent and analyse relationships between variables using dot plots (Mathematics).

	3. Describe, create and interpret data displays using median, mean and range (Mathematics). 4. Explain the limitations of extrapolating beyond recorded climate data (Mathematics and Science). 5. Analyse scientific reports and evaluate the credibility of such reports (Science).
Equipment required	**For the students**: Devices to access data from online sources *Student activity sheet 2.1: I see, I think, I wonder*
Preparation	Ensure students have access to the activity sheet. Organise a class set of photos for the *I see, I think, I wonder* activity in *Part 3.* A selection of images can be sourced online from webpages such as NASA's The Effects of Climate Change (see *Digital resources*). Print data sets from the Bureau of Meteorology website comparing weather and climate trends. Data sets that show multi-decadal trends will work best for comparison.
Activity parts	**Part 1: Australia's changing climate** Determine prior knowledge of climate change, greenhouse effect and global warming through class discussion. Do not provide any formal definitions or correct any answers as the purpose is to elicit students' prior knowledge. Broaden students' understanding by watching a selection of the videos in *Digital resources.* Ask students: • What does a changing climate mean for Australia? Using a think-pair-share oral language activity, students turn to a peer and for one minute, discuss their ideas and then actively listen when their partner is talking. See *Teacher resource sheet 1.2: Cooperative learning – Think-pair-share* for more information. Students share their partner's idea during class discussion. Record student responses using a class brainstorm.

Explain that climate is not static and across Australia and there is a wide range of climates, as well as considerable climate variability over time in any region which needs to be taken into account when looking at trends.

Refer students back to what they have learnt about the effect of the Sun and the position of the Earth on the seasons, and the protective effect of the atmosphere that saves the surface of the Earth from the extremes of the dangerous heat and other rays generated by the Sun.

It is helpful for students to understand how the atmosphere both reflects dangerous solar energy and allows enough heat through to warm up the surface of the Earth, and then prevents that heat from radiating back into space.

The Department of Agriculture, Water and the Environment has a simple diagram and information about this process and the effect of increasing greenhouse gases (see *Digital resources*).

Assist students to recognise how land loses heat faster than the ocean and how changes in temperature in the atmosphere affects the movement of air and interacts with weather variations and seasons to produce a given 'climate'. Also that climate encompasses the overall and longer-term weather conditions of a region including temperature, air pressure, humidity, precipitation, and sunshine.

Students may wish to play the Choose your climate future game to develop understandings (see *Digital resources*).

Part 2: Investigation and analysis of historical climate data

Explain to students they are going to locate relevant online data sources, extract data pertinent to their inquiry, analyse and interpret the data, and create an infographic to summarise and communicate their findings.

Direct students to the Bureau of Meteorology and Climate Change in Australia websites where they can obtain data about Australia's climate and weather events (see *Digital resources*).

Students work in ther groups to analyse and extrapolate climate data sets of their choice. For example, an analysis of rainfall, temperature, solar exposure and evaporation data will provide opportunities to identify trends over time, over regions of Australia and to identify relationships between climate variables.

Display a variety of available data sets to the class and conduct a brainstorm to identify questions that could guide students' inquiries.

Working in their groups, students identify the climate variable/s of interest and plan their inquiry. Encourage students to document the following in their journal:

Planning

- The selected weather variable/s
- Research question/s
- Data sources
- Data range – years, geographical region/s

Data analysis

- Description of the data
- Patterns/trends identified in the data.

Data interpretation

- Meaning/significance of the patterns/trends
- Implications of trends for the way we live
- Conclusion stating the answer to the research question/s.

Representation

- An infographic to summarise and communicate the findings of the inquiry.

Encourage students to think about spatial variations. For example, a wider regional scale is generally needed to identify trends, as patterns of climate variability can mask changes in the climate at the local scale, particularly for rainfall.

Encourage students to think about changes over time. Explain the need to search for trends over long periods, several decades or more. This allows the trend to show clearly against the background of year-to-year natural variability. Decisions based only on a short period of climate data could turn out to be poorly matched to future climate conditions.

Students should critically analyse the data, considering how long the data set is and how many stations' records it is based on. Data sets should be more than a few years old and have a regional/global analysis, averaging across many stations at each time point.

Engage students in planning a symposium where student groups share their findings with the class. Groups should be provided with a set time to present their findings.

In a plenary following the presentations discuss:

- What are the limitations of the data sources you used?
- Why did you choose certain periods or geographical regions?
- Can you trust the data? Why?
- What are your main findings about aspects of climate that are changing? What evidence do you have to support your claims?
- Were there any important relationships between any of the climate variables?
- How does knowing about pre-history world climatic changes such as the ice-ages relate to the more recent data?

Part 3: I see I think I wonder

Students use *Student activity sheet 2.1: I see, I think, I wonder* to display images about the effects of a changing climate. Images can be sourced online from webpages such as NASA's The Effects of Climate Change (see *Digital resources*).

Prompt class discussion by posing the following statements. Encourage students to share their opinions.

- Climate change won't affect people.
- Everyone is equally responsible for climate change.
- Everyone will be impacted by climate change in the same way.
- Climate change is just part of the natural cycle, the Earth's climate has always changed.
- Climate change is due to sunspots.
- CO_2 is a small part of the atmosphere – it can't have a large heating effect.
- Scientists manipulate all data sets to show a warming trend.
- Climate models are unreliable and too sensitive to carbon dioxide.
- Plants need carbon dioxide.

Part 4: A statistical analysis of temperature data

Explain that calculating the mean, median, mode and range from data sets helps to understand how the climate fluctuates above or below the average over time.

For example, if there is an exceptionally hot winter the mean and median of past winters can be calculated to determine if the winter is an anomaly or part of a warming trend. The range can determine the extent to which temperature is fluctuating over a given period. The temperature over a landmass and an ocean is important to weather and climate variables. They provide measures of global warming and surface sea temperatures affect the weather experienced on land.

Review with the students the meaning of and steps to calculate measures of central tendency and spread:

- The arithmetic mean, often called the average, helps determine if temperatures vary between periods. It can be calculated for daily, weekly, monthly, yearly or any period. To calculate the mean, add up all of the data points values and divide by the total number of data points. Students can more easily visualise this process as a group of friends putting all of their money together, and then sharing it out equally among everyone in the group.
- The median is the middle data point value which is another kind of average, but unlike the mean, is not skewed by outliers. To find the median temperature, all the data points should be arranged in order from least to greatest and the data value that has the same number of data points above and below it is the median value. If there is an even number of items in the data set, and the middle two values differ, then the median is the midpoint between the two middle values or the mean of those two values.
- The temperature mode or modes over a given period are the most commonly occurring temperatures. To calculate the mode, put the data points in order and count how many of each value. The data point or points that appear most often is the mode, or modes (there can be more than one mode).
- The range can be used to show how temperature varies over time. The range of a set of data is the difference between the highest and lowest values in the set. To find the range, subtract the smallest value from the largest value in the set.

Working in their groups, students use the BoM website to locate and analyse *Australian mean temperature anomaly* and *Australian sea surface temperature anomaly* data. Links are also provided in *Digital resources*.

Explain that anomaly data are calculated by comparing the annual figure with the long-term average for that variable. When graphed, these data show years when the temperature is below or above the long-term average.

Given that the data are based on annual figures, there is considerable fluctuation within the data and hence the trend is not easy to discern.

To adequately describe a data set, it is helpful to calculate measures of centre and spread. Students may choose to select the 1990–2019 data set or the 1960–2019 data set.

Challenge students to:

- Calculate the mean, median, mode and range for a selected period and then use these descriptive statistics to describe the data for both land and sea surface temperatures.
- Calculate five or 10-year average temperatures over an extended period and plot a dot plot graph of the data for both variables.
- Add a line of best fit to the data and describe the trend based on the recorded data.
- Extend the line of best fit to extrapolate beyond the data set to predict temperatures five, 10 and 20 years into the future, and explain how they confident they are of the various predicted temperatures based on their extrapolation.

Part 5: Effects of climate change

During heat waves, babies and the elderly are particularly vulnerable and death rates increase considerably. Dehydration diminishes the body's ability to regulate temperature, and thus, the risk of developing a heat illness rises dramatically. Heat illnesses are of special concern to senior citizens because older adults are much more affected by summer heat. Babies have a large surface area to volume ratio and thus are vulnerable to both dehydration and rapid changes in body temperature.

High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease. Pollen and other aeroallergen levels are also higher in extreme heat. These can trigger asthma, which affects around 300 million people. The Climate Council has released the *Heatwaves: Hotter, longer, more often* report on heatwaves in Australia (see *Digital resources*).

Challenge students to review this report and extract the main findings relating to the effects of climate change on health and the environment.

Prompt class discussion and student thinking by asking the following questions:

- How trustworthy/credible is this report? How do you know?
- What are the main impacts on human health?
- What are the main impacts on the environment?
- How might we adapt to the changes that are occurring?

Additional learning opportunity

Ask students to arrange the following in priority order: Books, stereo, shampoo, car, acceptance, self-esteem, bed, oxygen, friends, computer, shelter, education, health, TV, medicine, heat, food, air conditioning, clothes, refrigerator, electricity, hot water, bike, phone, toilet, tools, pets, meat, fuel, water.

Allow the class to discuss the order and, through mutual agreement and trial and error, arrange the words into a continuum, ranging from the most basic needs to items that are not essential to basic human life. Recognise cultures have the same fundamental needs and the variance is how people have met those needs.

As a class, discuss physical (nourishment, medicine, defence, transportation, clothing, shelter)and spiritual (religion, communication, art, music, dance)fundamental needs and if climate change could impact those needs. For example, the impact of lower rainfall in South West WA, increased land and sea temperature off the Western Australian coast and increased sea levels and storms.

Working in their groups, students brainstorm and record their ideas.

	Part 6: Reflection and journaling Provide time for students to reflect on and review what they have learnt. Useful prompts might include: • How do you determine if a set of data or a report is credible and trustworthy? • How useful are means, medians, modes and range for describing climate data? Explain why? *Because…* • What are the main changes to our climate as evidenced by recorded data? • What predictions can you make about temperatures in the future based on extrapolations from recorded data? How confident are you about these predictions? Why? *Because…* • What are the impacts of climate change on human health? • How might future cultures need to meet their fundamental needs differently from us today?
Resource sheets	*Student activity sheet 2.1: I see, I think, I wonder*
Digital resources	Evolution of technology Past to Present (Amit Ramesh, 2014) *youtu.be/NoX6mOg2EZQ*
	See how global warming has changed the world since your childhood (ABC News, 2019) *www.abc.net.au/news/2019-12-06/how-climate-change-has-impacted-your-life/11766018*
	Indigenous Weather Knowledge (Bureau of Meteorology, n.d.) *www.bom.gov.au/iwk/index.shtml*
	Annual rainfall, temperature and sea surface temperature anomalies and ranks (Bureau of Meteorology, 2019) *www.bom.gov.au/climate/current/annual/aus/2019/annual-summary-table.shtml*
	Annual climate statement 2019 (Bureau of Meteorology, 2020) *http://www.bom.gov.au/climate/current/annual/aus/2019/#tabs=Global*.
	Maps of average conditions (Bureau of Meteorology, 2013) *www.bom.gov.au/climate/averages/maps.shtml*
	Greenhouse effect (Department of Agriculture, Water and

	the Environment, n.d.) www.environment.gov.au/climate-change/climate-science-data/climate-science/greenhouse-effect
	The Effects of Climate Change (NASA, Global Climate Change, n.d.) climate.nasa.gov/effects/
	The Human Impact of Climate Change: Personal Stories from Australia (Climate Reality, 2013) youtu.be/b2V1Y1Mo4GU
	Heatwaves: Hotter, Longer, More Often (Climate Council, 2014) www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf
	Impacts of Climate Change in Australia (Climate Council, n.d.) www.climatecouncil.org.au/category/extreme-weather
	Climate Change 101 with Bill Nye (National Geographic, 2015) youtu.be/EtW2rrLHs08
	Climate Models video (Climate Change in Australia, n.d.) www.climatechangeinaustralia.gov.au/en/climate-campus/modelling-and-projections/climate-models/
	Climate change: Earth's giant game of Tetris - Joss Fong (TED-Ed, 2014) youtu.be/ztWHqUFJRTs
	Coastal Adaptation for climate change - 4 Residential (ParksVicEducation, 2012) youtu.be/ZePNCnODITQ
	Choose your climate future game (Earth Hour) Interactive resource showing the effects of global warming on home, community, sports, farming, environment and beach www.earthhour.org.au/Discover/climatefuture
	Interactive resource to show the effects of global warming on food and farming. What is climate change

Activity 3: Adapting to change

Activity focus

Students imagine, design and develop a technological solution to enable communities to adapt to climate changes.

Background information

Biological human evolution is a slow and gradual process by which the human species adapts to a changing environment. In times of rapid change to the environment, humans adapt to the change through new processes, systems and artefacts. This is a form of cultural evolution enabled by the development of new technologies such as processes of food production.

The article *Humans are still evolving – and scientists don't know why* has more information about human evolution and adaptation.

Adaptations to climate change occur in a range of contexts including natural ecosystems, agriculture, extreme weather events and human health.

Ecosystems

Animal and plant species migrating to a more suitable climate is one form of adaptation. However, there are challenges and obstacles for some species (for example, corals can only live in shallow water) in various ecosystems that make migration difficult, if not impossible. Some species may not be able to adapt and may become extinct.

Agriculture

Planting different crops that can withstand the impacts of climate change, breeding new plant species that are more tolerant to the changing conditions, changing the times of the year when crops are planted, and controlling insect pests may all be required to adapt agriculture to a changing climate.

Food production is responsible for 25% of all greenhouse gas emissions, which are causing Earth to warm too quickly. By changing what we eat and how it's produced we can moderate the rate of climate change (Our World in Data, 2019).

	Extreme weather Protecting the shores from storms and low lying areas from flooding, protecting water supplies from contamination by saltwater, improving early warning systems in the event of possible flooding, promoting and improving fire prevention and suppression practices may all be required to limit the impact of extreme weather conditions. **Human health** Strategies are required to help the community adapt to increasing ambient temperatures. These might include planting trees in cities to moderate the temperature, news and weather advisories to warn people about dangerous heat conditions, adjusting clothing to handle the temperature, monitoring and if necessary reducing activity levels to avoid exhaustion, increasing water intake, running programs to provide information about prevention and control of diseases.
Instructional procedures	To inform their solution design, students use their conceptual knowledge and information gathered from research in *Activity 1* and their investigations in *Activity 2*. **Design thinking** This activity is based on students engaging in design thinking which is part of both the Digital and Design and Technologies curriculum. It will require students to develop and follow a design brief, draw annotated plans and construct a working prototype that satisfies the design brief. See [Design process guide] for elaboration. It may be useful to review criteria for correctly labelled scientific diagrams with the students. See the link to *Scientific drawings* in the Digital resources section. The design process is a series of steps that guides the development of a solution to a problem. The solution should always be informed by gathering user information and then developed depending on the need and application. The core steps in the design process are the same whether applied in different contexts such as engineering or software design. These steps are:

- Define the problem: What is the need?
- Research and gather information.
- Analysis: Analyse and interpret the information.
- Ideation: Brainstorm ideas and pick the best idea, think through how will it work. Draw a diagram, identify materials or tools required?
- Development: Build the solution and test it.
- Evaluation: What works, what doesn't, what could work better? Repeat the cycle.

It is a process that is both cyclical and iterative and students should be encouraged not to focus on a single idea, especially at the start. It is unlikely that their first idea will be their best.

Students often find developing an authentic product or prototype that customers would want to be quite challenging. Typically, many assumptions are made about the end-user of the product that is not based on any factual evidence. Questioning can challenge presumptions. For example, *How do you know that? How can you check that? Is that a guess or do you know that for sure?* will help students better understand the user. Making some assumptions is ok, but those should be tested by testing a prototype on the user.

The statement *How might we…?* is important to show that the suggested solution is not final and encourages the use of the design process to think of all the possibilities and choose the best idea to trial and test first.

It should be recognised that to design an electronic or digital system in the real world requires a level of electrical and software engineering that may or may not be a skill for Year 7 students. However, if students feel competent using physical computing platforms such as *micro:bit, Raspberry Pi* or *Arduino* to bring their ideas into reality, then they should be encouraged to do so.

In the case of more adventurous or ambitious digital solutions which cannot be produced in a classroom environment, students may elect to supplement their physical mockups with animation or interactive software which demonstrates their approach. For example, the most recent version of the popular programming language *Scratch* includes a video sensing feature which can respond to movement in the camera's field of view. One

	possible application of this might be the development of an alert system for slips, trips or falls. The teacher should act as a facilitator during this activity, encouraging students to collaboratively develop their design brief. This gives students ownership of the creative process and encourages their creativity. Presentations should be prepared in groups. To scaffold cooperative group work, each member of the group could have a role and responsibility. For example, one could be the Content Director, one the Media Director and a Presentation Director. All students in the group would contribute to deciding on the content, preparing the media and giving the presentation, while one student has overall responsibility for managing that phase of the task. See *Teacher resource sheet 1.1: Cooperative learning – Roles* for more information. **Collecting evidence** Students continue to populate physical or digital portfolios or journals from previous activities to contribute towards a greater body of work for later assessment. This may take the form of research work, photos, digitally produced flow charts, digital framework, mockups or a working prototype. See *Student journal* for further information.
Expected learning	Students will be able to: 1. Work collaboratively to plan, safely develop and communicate ideas and information about their proposed solution (Technologies). 2. Address competing social, ethical and sustainability considerations when designing products or services (Technologies). 3. Develop criteria to evaluate and justify the design of their solution (Technologies). 4. Communicate design ideas, plans and processes using a range of techniques, appropriate technical terms and technology (Technologies). 5. Explain and justify design choices drawing on scientific evidence and principles (Science).
Equipment required	**For the class:** Access to the Rapid Design Sprint Kit *and* sets of canvases (see *Digital resources)*

	Sticky notes Access to internet-connected automation services such as *If This Then That* (see *Digital resources*) The equipment required by students will depend on the type of technological solution being developed whether it be a service, process, system or artefact. If students are creating a physical solution prototype, see *Materials list*.
	For the students: Markers (one per student) A3 paper (one per student)
Preparation	Make available a copy of the *Rapid Design Sprint Kit*. Select sets of *Rapid Design Sprint Kit* canvases that can be used with the design thinking process. Depending on your timeframe, students could work through a variety of these canvases. This module picks out a few that might help guide students for this particular project. Prepare a 40-second interval timer (see *Digital resources*) Organise a suitable space where students can make their prototypes. Source materials and equipment for students to build prototypes. Ensure students know how to use all equipment before using it.
Activity parts	**Part 1: Defining the problem, identifying needs and developing a design brief** Drawing on their findings in *Activities 1 and 2*, students review the main changes that are occurring in the Australian environment. Remind students of the problem being addressed: *How can technology help us respond to a changing environment?* Working in groups, students identify the impacts of a changing climate on people. Once the impacts have been identified, students consider the needs of a particular group of people and how these might be met. To support the planning and development of a solution for their clients, students prepare a design brief which should include:

- A statement of the problem
- The needs of the client
- A list of success criteria that can be used to evaluate the extent to which the solution successfully meets the needs of the client.

Students should document their design brief in their journal and include initial thinking as *How might we …* statements.

Part 2: Generating ideas

Students undertake a rapid prototype approach to generate ideas to address the problem:

- Students fold an A3 piece of paper into eight and write Idea 1, Idea 2 etc in each of the eight rectangles.
- Students generate ideas based on their *How might we…* statement they have chosen for their group.
- Remind students that solutions should meet the criteria of the project (a technological solution either digital or physical).
- Each student represents an idea using a picture (not words) in the rectangle marked Idea 1.
- Every 40 seconds, students continue to generate new ideas until all eight rectangles are full.

Students may reach a point where they find it difficult to generate new ideas and require a prompt:

- An idea that will help the people that support the persons affected take better care of them.
- Take one idea and make it better.
- Take two of your ideas and merge them.

Ask students:

- What was the most challenging part of the activity?
- If I had asked you to create eight ideas in five minutes, do you think you would have achieved it? Why? Why not?
- Are your ideas varied or similar? Why is that?

Student groups review the ideas generated and rank them in order of potential to effectively address the problem for the client.

Part 4: Refining potential solutions

Based on their ideas for potential solutions, students discuss and review their top-ranked ideas in the context of findings from *Activities 1* and 2 and the needs of their client.

Scaffold student thinking through questioning:

- Is your focus area manageable or are you trying to cover too much?
- What are the particular issues associated with your focus area that you feel strongly about?
- Do you need to gather further information about your client's needs?
- How would you develop this particular solution, what resources would be required?
- What social, ethical and sustainability considerations need to be addressed?

When the group and the teacher are satisfied that the group's idea for a solution and how it would be developed is clear and comprehensive, the group progresses to storyboarding.

Part 5: Storyboarding

Groups develop their idea into a prototype of their product by defining what their product is, testing any risky assumptions and describing how the user will experience it.

Using a storyboard approach, students depict the process of developing the prototype and how the user would experience it.

If students are unfamiliar with storyboarding there are many instructional videos, such as *Intro to Storyboarding*, see *Digital resources*.

Part 6: Prototyping

Prototypes are iterations of a developing product. Encourage students to think about the quickest and easiest way to test their ideas so they can gather feedback on the product to improve it.

Using the feedback gathered, student groups revise and improve their prototype.

Part 7: Creating the presentations

Support students to create their presentations and/or displays for the advocacy campaign in *Activity 4*. Some students may require software for a digital presentation, opportunity to take photos, time to create a script and act out a video production that highlights their messages. Others may wish to create posters or physical displays, or combinations of technology and hard copy. See *Digital resources* for ideas and examples.

Provide students with time and encouragement to explore options and try out different ways to deliver their messages, seeking feedback from the teacher and other groups.

Part 8: Reflection and journaling

At different times during the design process, ask students to record their reflections in their journal. This can include an evaluation of their progress and their group's planning processes.

Prompt student reflections by asking:

- How have you shared out the responsibilities in your group?
- Have you made use of individual group member's particular strengths?
- Is what you had planned in your design brief manageable? If not, how have you adapted it?
- What new ideas have you incorporated as you implemented your design brief?
- How is your proposed solution based on scientific evidence?
- How have you managed your time so that you will be ready for the campaign date?
- Are you satisfied that your solution is successful in addressing your design brief? Why or why not?

Digital resources

Samsung predicts the world 100 years from now (Futuretimeline.net, 2016) www.futuretimeline.net/blog/2016/02/24.htm#.V6TobDt97IU

Humans are still evolving – and scientists don't know why (Lawrence D Hurst, The Independent, 2018) www.independent.co.uk/news/science/human-evolution-dna-natural-selection-dna-genetic-mutation-why-a8641536.html

Scientific drawings (Cool Australia, 2016) prod-media.coolaustralia.org/wp-content/uploads/2016/03/06192815/Scientific-drawing-guidelines.pdf

	Rapid Design Sprint Kit toolkit (Skills of the Modern Age) *skillsofthemodernage.com.au/tools/rapid-design-sprint-toolkit/* Persona canvas, page 9 Empathy canvas, page 10 Point of view canvas, page 11 How might we's canvas, page 12 Crazy 8s canvas, page 13 Idea ranking canvas, page 14 Idea sketch canvas, page 15 Assumptions canvas, page 16 Lean plan canvas, page 17 Storyboard canvas, page 19
	60-Second Strategy: TAG Feedback (Edutopia, 2019) *youtu.be/HM5dp50HWXQ*
	TAG Feedback Sentence Starters (Nepris store, n.d.) *neprisstore.blob.core.windows.net/sessiondocs/doc_6e22ed17-60e8-41e5-8dcc-1e7d80534b49.pdf*
	If This Then That *ifttt.com*
	40-second interval timer (Kai Patient, 2014) *youtu.be/G-JSdCqai1Q*
	Intro to Storyboarding video (RocketJump Film School, 2016) *youtu.be/RQsvhq28sOI*
	Images predicting technological/building changes 100 years into the future *www.telegraph.co.uk/finance/newsbysector/constructionandproperty/12157503/Humans-will-live-underwater-in-100-years-time-as-the-population-is-squeezed-out-of-cities.html*

Activity 4: Advocacy campaign

Activity focus 	Students share their ideas through a public event to showcase their analysis of climate change, how it impacts on their client and the solutions they have developed to address their client's needs.
Instructional procedures	The showcase develops authenticity for the student groups and encourages their voices to be heard. By putting students in charge of the showcase they not only develop important event management skills, but they are also in charge of advocating for their products. Students understand that by bringing attention to issues it is possible to advocate and effect change. The presentations provide a rich opportunity for assessing the students' understanding of the science and technology principles and processes, their mathematical thinking as well as literacies associated with speaking and listening. The preparation and management of the showcase should be the students' joint responsibility. This will give students agency over their learning and help foster critical analysis. With guidance, they will be required to make value judgements and develop skills in negotiation and conflict resolution as they navigate the event. There does need to be a framework around the product showcase as it is likely that the students will have limited experience of preparing such an event. Students must have a chance to showcase their work to an authentic audience. Including a visitor with an interest in the topic to the audience will increase students' engagement and learning from the task. The project reflection is arguably the most important of all the tasks in the project and where the real consolidation of deep learning transpires. The meta-learning aspect of the reflection process helps students to understand what they have learnt about learning and learning processes. The showcase is a celebration of student learning. The more authentic the audience is, the more students will be engaged in the project.

	Preparing the presentations Students will need support and scaffolding to prepare for their presentation. To scaffold cooperative group work, each member of the group could have a role and responsibility. For example, one could be the Content Director, one the Media Director and a third the Presentation Director. All students contribute to all aspects of the presentation, with one student having overall responsibility for managing that phase of the task. See *Teacher resource sheet 1.1: Cooperative learning – Roles* for more information. **Using Information and communication technology (ICT)** Digital options for presentations include creating a comic strip, *eBook*, poster in *Pages*, *Keynote* or *PowerPoint* or *iMovie* (or similar). Photographs taken throughout the design process should be used in digital presentations. The presentation may be shared through a platform such as *Seesaw*, *Class Dojo* or *Connect,* added to a class blog or shared on an interactive whiteboard. Students may require explicit instruction in using these apps.
Expected learning	Students will be able to: 1. Work collaboratively to create a multimodal presentation to communicate design solutions (Technologies). 2. Explain mathematical modelling and its reliability in predicting future climate conditions (Mathematics). 3. Justify design choices using science understandings and evidence (Science). 4. Evaluate the success of the proposed solution using success criteria linked to client needs (Technologies). 5. Explain how competing social, ethical and sustainability considerations were addressed in the design of their product or service (Technologies).
Equipment required	**For the class:** Multimedia specific to students' presentation requirements
	For the students: Digital devices loaded with appropriate apps for multimedia presentations Collection of all the artefacts created through the project Reflection journals

[Student activity sheet 4.1: Presentation review]()

[Student activity sheet 4.2: Ladder of feedback]()

[Student activity sheet 4.3: Self- evaluation]()

Preparation

Ensure the technology and media are available.

Invite local community experts to view the final student presentations.

Some considerations teachers may have to make include:

Venue and time

- Possibly a certain area of the school.
- An afternoon/early evening after school.

Invitations

- Who do you want to attend?
- Are there any known professionals you can invite?
- How will you raise awareness of the event?

Students need to set up their event space and make sure they have all the materials they require.

Activity parts

Part 1: Introduction

Explain to the students they will create a presentation to display their data analysis and design solutions at a showcase event.

Students are encouraged to be creative with their presentations, some ideas could include:

- 3D model
- Print
- Technology
- *Scratch*, digital labelled diagram, eBook, *Puppet pals*, *iMovie*, etc.
- Report; written or verbal

See *Digital resources* for suggestions.

Part 2: Planning the event

Hold a class discussion to plan the showcase event. Questions to be resolved as part of this process include:

- When will it be held, and for how long should it last?
- Where will we hold it? How many do we expect to come? How much space will we need? How many different displays will there be?

- Should we send invitations or just advertise it? If so, how will we advertise it?
- How will we organise the space? Will we need tables and chairs? What technology will we need on the day?
- Will we provide any refreshments, and if so, how will we pay for them?
- Do we need to have a keynote speaker to set the scene for the day? Who could that be and what would we want them to talk about?

With student input, create a timeline and tasks that need to be completed leading up to the event. Also, as a class, create a task sheet for the day to ensure it runs smoothly.

Engage students at every stage of the planning, accepting their suggestions as appropriate.

Part 3: Planning for evaluation

Discuss with the class how they can find out whether or not the showcase was successful in developing understandings about our changing climate and advocating for their proposed solutions.

Ask students to design a simple feedback questionnaire that visitors to the showcase event can complete on the day to provide data to evaluate the success of the event.

Part 4: Choosing media and creating presentations

Working in their groups, students use a chosen form of media to communicate their design process and solution.

Set expectations for oral presentations. Create an environment where the audience can actively listen to and engage with presenters.

Explain to students that the purpose of the presentation is to support participants' understanding and awareness of:

- A changing climate and how human activities are contributing towards this
- Empathy for people and communities affected by a changing climate
- How a changing climate impacts on people
- Innovative technological developments enabling humans to adapt to climate change.

	Part 5: The showcase event Provide an opportunity for groups to practise their presentations before the event and have other groups provide constructive feedback to assist them to improve their presentations. Ensure that the digital equipment is charged and loaded with apps as needed and tested before the day. If possible, a local expert could attend the event to discuss the importance of awareness about a changing climate from an industry or community perspective, and the important role of innovation and technology. Hand out the feedback sheets and provide pencils and a table to make it easy for visitors to complete. Arrange for photos and/or a video to be taken on the day to be reviewed in class. Remind students to thank visitors for attending. Ensure students assist in the clean up at the end of the day so that the venue is left as it was found.
	Part 6: Reviewing the day Students watch the video and/or photos from the event, review the feedback sheets and collate the data. Assist students to interpret the data and celebrate their successes. As a class, produce a report on the event to go into the school newsletter or in the local paper, including summary data from the feedback sheets. To consolidate their learning experiences, conduct a class discussion to scaffold students' reflections on how their investigations provided the evidence to formulate a solution to a community problem, how their thinking evolved, and the ways their design changed over time. Ask students to consider how they would improve their presentations if they were to repeat the showcase.
	Part 7 Self-reflection and evaluation Students conduct a review and reflection prompted by focus questions:

	- How were your suggestions for future environments and subsequent living conditions for humans informed by your research and investigations? - How important were science and mathematics for helping you understand the issue? - In what ways did your thinking change about the future of life on Earth through the research and design processes? What specifically made your thinking change? - How effective do you think your presentation was? - How could you strengthen and improve your presentation if repeated? Students peer review their designs and presentation using *Student activity sheet 4.1: Presentation review* and *Student activity sheet 4.2: Ladder of feedback* as they consider the success criteria identified in *Activity 3*. Students to complete *Student activity sheet 4.3: Self-evaluation* and *Student activity sheet 1.0: Journal checklist*. This is also a good opportunity for teachers to complete *Teacher resource sheet 4.4: Student evaluation* and *Teacher resource sheet 4.5: 3-2-1 Reflection*
Resource sheets	*Student activity sheet 4.1: Presentation review* *Student activity sheet 4.2: Ladder of feedback* *Student activity sheet 4.3: Self-evaluation* *Teacher resource sheet 4.4: Student evaluation* *Teacher resource sheet 4.5: 3-2-1 Reflection*
Digital resources	iMovie *www.apple.com/au/imovie*
	eBook *www.ebooks.com*
	Puppet pals *apps.apple.com/au/app/puppet-pals-hd/id342076546*
	Scratch *www.scratch.mit.edu* *splash.abc.net.au/home#!/digibook/2427023/introduction-to-scratch*

Appendix 1: Links to the Western Australian Curriculum

The *Climate calculations* module provides opportunities for developing students' knowledge and understandings in science, technologies and mathematics. The table below shows how this module aligns to the content of the Western Australian Curriculum and can be used by teachers for planning and monitoring.

Climate calculations Links to the Western Australian Curriculum	ACTIVITY			
	1	**2**	**3**	**4**
SCIENCE				
SCIENCE UNDERSTANDING				
Earth and space sciences: Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)	●			
SCIENCE AS A HUMAN ENDEAVOUR				
Use and influence of science: Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)			●	
SCIENCE INQUIRY SKILLS				
Questioning and predicting: Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)		●	●	
Processing and analysing data and information: Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSSIS129)		●	●	
Processing and analysing data and information: Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)		●		

Climate calculations Links to the Western Australian Curriculum	ACTIVITY			
	1	**2**	**3**	**4**
SCIENCE				
SCIENCE INQUIRY SKILLS				
Evaluating: Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132)		●		
Communicating: Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)				●
DESIGN AND TECHNOLOGIES				
KNOWLEDGE AND UNDERSTANDING				
Technologies and society: Competing factors, including social, ethical and sustainability considerations, in the development of technologies (ACTDEK029)		●	●	
Designing: Design, develop, review and communicate design ideas, plans and processes within a given context, using a range of techniques, appropriate technical terms and technology (WATPPS41)			●	
Evaluating: Independently apply given contextual criteria to evaluate design processes and solutions (WATPPS44)			●	●
Collaborating and managing: Work independently, and collaboratively when required, to plan, develop and communicate ideas and information, using management processes (WATPPS45)	●	●	●	●
DIGITAL TECHNOLOGIES				
PROCESSES AND PRODUCTION SKILLS				
Collecting, managing and analysing data: Explore how to acquire data from a range of digital sources (ACTDIP025)		●		

Climate calculations Links to the Western Australian Curriculum	ACTIVITY 1	2	3	4
MATHEMATICS				
STATISTICS AND PROBABILITY				
Data representation and interpretation: Identify and investigate issues involving numerical data collected from primary and secondary sources (ACMSP169)		●		
Data representation and interpretation: Construct and compare a range of data displays including stem-and-leaf plots and dot plots (ACMSP170)		●		
Data representation and interpretation: Calculate mean, median, mode and range for sets of data. Interpret these statistics in the context of data (ACMSP171)		●		
Data representation and interpretation: Describe and interpret data displays using median, mean and range (ACMSP172)		●		
NUMBER AND ALGEBRA				
Real numbers: Recognise and solve problems involving simple ratios (ACMNA173)	●			
Real numbers: Multiply and divide fractions and decimals using efficient written strategies and digital technologies (ACMNA154)	●	●		
Real numbers: Round decimals to a specified number of decimal places (ACMNA156)	●			
Number and place value: Investigate index notation and represent whole numbers as products of powers of prime numbers (ACMNA149)	●			
Linear and non- linear relationships: Investigate, interpret and analyse graphs from authentic data (ACMNA180)		●		
MEASUREMENT AND GEOMETRY				
Year 6 content – Units of Measurement: Convert between common metric units of length, mass and capacity (ACMMG136)	●			

Further information about assessment and reporting in the Western Australian Curriculum can be found at k10outline.scsa.wa.edu.au/home.

Appendix 1B: Mathematics proficiency strands

Key ideas

In Mathematics, the key ideas are the proficiency strands of understanding, fluency, problem-solving and reasoning. The proficiency strands describe the actions in which students can engage when learning and using the content. While not all proficiency strands apply to every content description, they indicate the breadth of mathematical actions that teachers can emphasise.

Understanding

Students build a robust knowledge of adaptable and transferable mathematical concepts. They make connections between related concepts and progressively apply the familiar to develop new ideas. They develop an understanding of the relationship between the 'why' and the 'how' of mathematics. Students build understanding when they connect related ideas, when they represent concepts in different ways, when they identify commonalities and differences between aspects of content, when they describe their thinking mathematically and when they interpret mathematical information.

Fluency

Students develop skills in choosing appropriate procedures; carrying out procedures flexibly, accurately, efficiently and appropriately; and recalling factual knowledge and concepts readily. Students are fluent when they calculate answers efficiently, when they recognise robust ways of answering questions, when they choose appropriate methods and approximations, when they recall definitions and regularly use facts, and when they can manipulate expressions and equations to find solutions.

Problem-solving

Students develop the ability to make choices, interpret, formulate, model and investigate problem situations, and communicate solutions effectively. Students formulate and solve problems when they use mathematics to represent unfamiliar or meaningful situations, when they design investigations and plan their approaches, when they apply their existing strategies to seek solutions, and when they verify that their answers are reasonable.

Reasoning

Students develop an increasingly sophisticated capacity for logical thought and actions, such as analysing, proving, evaluating, explaining, inferring, justifying and generalising. Students are reasoning mathematically when they explain their thinking, when they deduce and justify strategies used and conclusions reached, when they adapt the known to the unknown, when they transfer learning from one context to another, when they prove that something is true or false, and when they compare and contrast related ideas and explain their choices.

Source: ACARA - www.australiancurriculum.edu.au/f-10-curriculum/mathematics/key-ideas/?searchTerm=key+ideas#dimension-content

Appendix 2: General capabilities continuums

The general capabilities continuums shown here are designed to enable teachers to understand the progression students should make with reference to each of the elements. There is no intention for them to be used for assessment.

Information and communication technology (ICT) capability learning continuum

Sub-element	Typically by the end of Year 4	Typically by the end of Year 6	Typically by the end of Year 8
Create with ICT **Generate ideas, plans and processes**	use ICT to generate ideas and plan solutions	use ICT effectively to record ideas, represent thinking and plan solutions	use appropriate ICT to collaboratively generate ideas and develop plans
Create with ICT **Generate solutions to challenges and learning area tasks**	create and modify simple digital solutions, creative outputs or data representation/ transformation for particular purposes	independently or collaboratively create and modify digital solutions, creative outputs or data representation/transformation for particular audiences and purposes	design and modify simple digital solutions, or multimodal creative outputs or data transformations for particular audiences and purposes following recognised conventions
Communicating with ICT **Collaborate, share and exchange**	use appropriate ICT tools safely to share and exchange information with appropriate known audiences	select and use appropriate ICT tools safely to share and exchange information and to safely collaborate with others	select and use appropriate ICT tools safely to lead groups in sharing and exchanging information, and taking part in online projects or active collaborations with appropriate global audiences

Critical and creative thinking learning continuum

Sub-element	Typically by the end of Year 4	Typically by the end of Year 6	Typically by the end of Year 8
Inquiring – identifying, exploring and organising information and ideas **Organise and process information**	collect, compare and categorise facts and opinions found in a widening range of sources	analyse, condense and combine relevant information from multiple sources	critically analyse information and evidence according to criteria such as validity and relevance
Generating ideas, possibilities and actions **Imagine possibilities and connect ideas**	expand on known ideas to create new and imaginative combinations	combine ideas in a variety of ways and from a range of sources to create new possibilities	draw parallels between known and new ideas to create new ways of achieving goals
Generating ideas, possibilities and actions **Seek solutions and put ideas into action**	experiment with a range of options when seeking solutions and putting ideas into action	assess and test options to identify the most effective solution and to put ideas into action	predict possibilities, and identify and test consequences when seeking solutions and putting ideas into action
Reflecting on thinking and processes **Transfer knowledge into new contexts**	transfer and apply information in one setting to enrich another	apply knowledge gained from one context to another unrelated context and identify new meaning	justify reasons for decisions when transferring information to similar and different contexts

Personal and social capability learning continuum

Sub-element	Typically by the end of Year 4	Typically by the end of Year 6	Typically by the end of Year 8
Social management **Work collaboratively**	describe characteristics of cooperative behaviour and identify evidence of these in group activities	contribute to groups and teams, suggesting improvements in methods used for group investigations and projects	assess the extent to which individual roles and responsibilities enhance group cohesion and the achievement of personal and group objectives
Social management **Negotiate and resolve conflict**	identify a range of conflict resolution strategies to negotiate positive outcomes to problems	identify causes and effects of conflict, and practise different strategies to diffuse or resolve conflict situations	assess the appropriateness of various conflict resolution strategies in a range of social and work-related situations
Social management **Develop leadership skills**	discuss the concept of leadership and identify situations where it is appropriate to adopt this role	initiate or help to organise group activities that address a common need	plan school and community projects, applying effective problem-solving and team-building strategies, and making the most of available resources to achieve goals

Further information about general capabilities is available at *k10outline.scsa.wa.edu.au/home/p-10-curriculum/general-capabilities-over/general-capabilities-overview/general-capabilities-in-the-australian-curriculum*

Appendix 3: Materials list

The following are required to complete this module.

Materials

- Craft materials
- Woodwork/metal/plastic material
- Fabrics
- Recyclable materials (cardboard, plastic, metal containers)

Digital

- Computers, laptops or tablet devices for creating device firmware
- Physical computing devices and controllers (eg *Makey Makey, micro:bit, Code Bug, LilyPad, Raspberry Pi, Arduino*)
- Additional peripherals such as sensors, motors, servos and power supplies

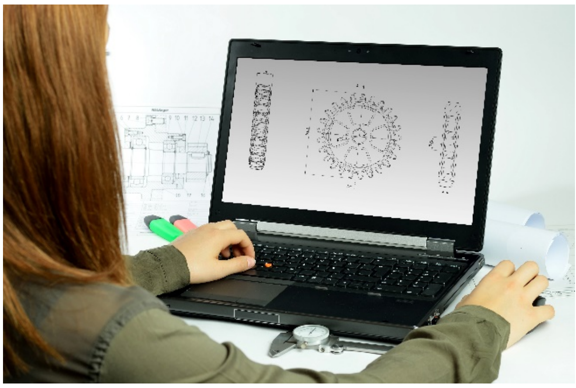
Equipment (optional)

- Glue guns
- Soldering irons
- 3D printers
- Laser cutters
- Cutting equipment
- Woodwork/metalwork/plastic equipment
- Sewing machines

Appendix 4: Design process guide

Research	**Finding useful and helpful information about the design problem.** Gathering information, conducting surveys, finding examples of existing solutions, testing properties of materials, practical testing.
Analysis	**Understanding the meaning of the research findings.** Analysing what the information means, summarising the surveys, judging the value of existing solutions, understanding test results.
Ideation	**Idea generation – turning ideas into tangible forms so they can be organised, ordered and communicated to others.** Activities such as brainstorming, mind mapping, sketching, drawing diagrams and plans, collecting colour samples and/or material samples and talking through these ideas can help to generate creative ideas. Using the **SCAMPER** model can assist with this: *www.mindtools.com/pages/article/newCT_02.htm* *www.designorate.com/a-guide-to-the-scamper-technique-for-creative-thinking*
Development	**Development of the design ideas. Improvements, refinements, adding detail, making it better.** Activities such as detailed drawings, modelling, prototyping, market research, gaining feedback from intended user, further research – if needed – to solve an issue with the design, testing different tools or equipment, trialling production processes, measuring or working out dimensions, testing of prototypes and further refinement.
Production	**Safe production of the final design or multiple copies of the final design**. Fine tuning the production process, such as division of labour for batch or mass production. Use of intended materials and appropriate tools to safely make the solution to the design problem.
Evaluation	**Reflection on the process taken and the success of the design.** Evaluation can lead to further development or improvement of the design and can be a final stage of the design process before a conclusion is reached. Could be formal or informal and verbal or written.

Appendix 4B: Drawing in the design process



istockphoto.com

Incorporating the design process into the STEM modules will often result in the need for students to draw plans of their designs. This can be done at a simple level using hand-drawn sketches or at a more technical level using computer-aided design (CAD).

By developing skills using industry-standard software, students may be well-placed to explore future career pathways.

There are several CAD software options; two free examples are detailed below. *Autodesk* is a third package that is also free for educational use.

Tinkercad

- Format: Web-based app requiring internet access via a browser
- Purpose: A simple, online 3D design and 3D printing app
- Home: *www.tinkercad.com*
- Blog: *blog.tinkercad.com*
- Tutorials: *www.tinkercad.com/learn*
- Feature: Connects to 3D printing and laser cutting.

SketchUp

- Format: Can be downloaded and installed on devices, or used in a browser
- Purpose: Enables students to draw in 3D
- Home: *www.sketchup.com* 'Products' '*SketchUp for Schools*'
- Help centre: *help.sketchup.com/en*
- Blog: *blog.sketchup.com*
- Tutorials: *www.youtube.com/user/SketchUpVideo*. From beginner tool tips to intermediate and advanced modelling techniques, the video tutorials help to build *SketchUp* skills.

Appendix 5: Student journal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When students reflect on learning and analyse their ideas and feelings, they self-evaluate, thereby improving their metacognitive skills.

This module encourages students to self-reflect and record the stages of their learning in a journal, which may take the form of a written journal, a portfolio or a digital portfolio.

Using digital portfolios can help develop students' information and communication technology (ICT) capability.

Reflective practice and recording can be supported in classrooms by creating opportunities for students to think about and record their learning through notes, drawings or pictures. Teachers should encourage students to revisit earlier journal entries to help them observe the progress of their thoughts and understanding.

Journals are a useful tool that gives teachers additional insight into how students value their own learning and progress, as well as demonstrating their individual achievements.

The following links provide background information and useful apps for journaling.

Reflective journal (University of Technology Sydney) www.uts.edu.au/sites/default/files/reflective_journal.pdf
Reflective writing (University of New South Wales Sydney)) student.unsw.edu.au/reflective-writing
Balancing the two faces of ePortfolios (Helen Barrett, 2009) electronicportfolios.org/balance/Balancing.jpg
Digital portfolios for students (Cool tools for school) cooltoolsforschool.wordpress.com/digital-student-portfolios
Kidblog – digital portfolios and blogging kidblog.org/home
Evernote (a digital portfolio app) evernote.com
Weebly for education (a drag and drop website builder) education.weebly.com
Connect – the Department of Education's integrated, online environment connect.det.wa.edu.au

Appendix 6: Student activity sheet 1.0: Journal checklist

As an ongoing part of this module, you have been keeping a journal of your work.

Before submitting your journal to your teacher please ensure you have included the following information.

- Tick each box once complete and included.
- Write N/A for items that were not required in this module.

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Your name and group member's names or photographs	
An explanation of the problem you are solving	
Your notes from *Activity 1*	
Your notes from *Activity 2*	
Your notes from *Activity 3*	
Your notes from *Activity 4*	
Student activity sheet 1.4: Solar system to scale	
Student activity sheet 2.1: I see, I think, I wonder	
Student activity sheet 4.1: Presentation review	
Student activity sheet 4.2: Ladder of feedback	
Student activity sheet 4.3: Self-evaluation	

Student activity sheet 1.0: Journal checklist	

Appendix 7: Teacher resource sheet 1.1: Cooperative learning – Roles

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Cooperative learning frameworks create opportunities for groups of students to work together, generally to a single purpose.

As well as having the potential to increase learning for all students involved, using these frameworks can help students develop personal and social capability.

When students are working in groups, positive interdependence can be fostered by assigning roles to group members.

These roles could include:

- Working roles such as Reader, Writer, Summariser, Timekeeper
- Social roles such as Encourager, Observer, Noise monitor, Energiser.

Teachers using the *Primary Connections* roles of Director, Manager and Speaker for their science teaching may find it effective to also use these roles for STEM learning.

Further to this, specific roles can be delineated for specific activities that the group is completing.

It can help students if some background to the purpose of group roles is made clear to them before they start, but at no time should the roles get in the way of the learning. Teachers should decide when or where roles are appropriate to given tasks.

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Appendix 8: Teacher resource sheet 1.2: Cooperative learning – Think-pair-share

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Cooperative learning frameworks create opportunities for groups of students to work together, generally to a single purpose.

As well as having the potential to increase learning for all students involved, using these frameworks can help students develop personal and social capability.

The think-pair-share strategy increases student participation and provides an environment for higher levels of thinking and questioning.

In the 'think' stage, each student thinks silently about a question asked by the teacher.

In the 'pair' stage, students discuss their thoughts and answers to the question in pairs.

In the 'share' stage, students share their answer, their partner's answer or what they decided together. This sharing may be with other pairs or with the whole class. It is important also to let students 'pass'. This is a key element of making the strategy safe for students.

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Appendix 9: Teacher resource sheet 1.3: Cooperative learning – Jigsaw

Cooperative learning frameworks create opportunities for groups of students to work together, generally for a single purpose.

As well as having the potential to increase learning for all students involved, using these frameworks can help students develop personal and social capability.

The jigsaw strategy typically has each member of the group becoming an 'expert' on one or two aspects of a topic or question being investigated. Students start in their cooperative groups, then break away to form 'expert' groups to investigate and learn about a specific aspect of a topic. After developing a sound level of understanding, students return to their cooperative groups and teach each other what they have learnt.

Within each expert group, issues such as how to teach the information to their group members are considered.

<table>
<tr><td>Step 1</td><td>Cooperative groups
(of four students)</td><td colspan="2">1 2 3 4</td><td colspan="2">1 2 3 4</td></tr>
<tr><td>Step 2</td><td>Expert groups
(size equal to the number of groups)</td><td>1 1</td><td>2 2</td><td>3 3</td><td>4 4</td></tr>
<tr><td>Step 3</td><td>Cooperative groups
(of four students)</td><td colspan="2">1 2 3 4</td><td colspan="2">1 2 3 4</td></tr>
</table>

Appendix 10: Student activity sheet 1.4: Solar system to scale

<table>
<tr><td colspan="4">Approximate scaled diameter of the Sun in cm:</td><td rowspan="3">New scaled diameter of the Sun in cm:</td><td rowspan="3">1 km = 1000 m
1 km = 100 000 cm
1 km = 1 000 000 mm</td></tr>
<tr><td colspan="4">Scaled diameter of the Sun in km:</td></tr>
<tr><td colspan="4">Rounded scale factor:</td></tr>
<tr><td>Name</td><td>Diameter (km)</td><td>Scaled diameter</td><td>Distance from the Sun (km)</td><td>Distance in index notation (km)</td><td>Scaled distance (cm)</td></tr>
<tr><td>Sun</td><td>1 391 900</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mercury</td><td>4 866</td><td></td><td>57 950 000</td><td></td><td></td></tr>
<tr><td>Venus</td><td>12 106</td><td></td><td>108 110 000</td><td></td><td></td></tr>
<tr><td>Earth</td><td>12 742</td><td></td><td>149 570 000</td><td></td><td></td></tr>
<tr><td>Mars</td><td>6 760</td><td></td><td>227 840 000</td><td></td><td></td></tr>
<tr><td>Jupiter</td><td>142 984</td><td></td><td>778 140 000</td><td></td><td></td></tr>
<tr><td>Saturn</td><td>116 438</td><td></td><td>1 427 000 000</td><td></td><td></td></tr>
<tr><td>Uranus</td><td>46 940</td><td></td><td>2 870 300 000</td><td></td><td></td></tr>
<tr><td>Neptune</td><td>45 432</td><td></td><td>4 499 900 000</td><td></td><td></td></tr>
<tr><td>Pluto</td><td>2 274</td><td></td><td>5 913 000 000</td><td></td><td></td></tr>
</table>

Appendix 11: Student activity sheet 2.1: I see, I think, I wonder

What do you see when you look at this image?	 *Pixabay.com*
What are you thinking about as you look at this image?	 *Pixabay.com*
What are your wonderings (questions)?	 *Pixabay.com*

Information about the *I see, I think, I wonder* cooperative strategy can be found at pz.harvard.edu/resources/see-think-wonder-at

Appendix 12: Student activity sheet 4.1: Presentation review

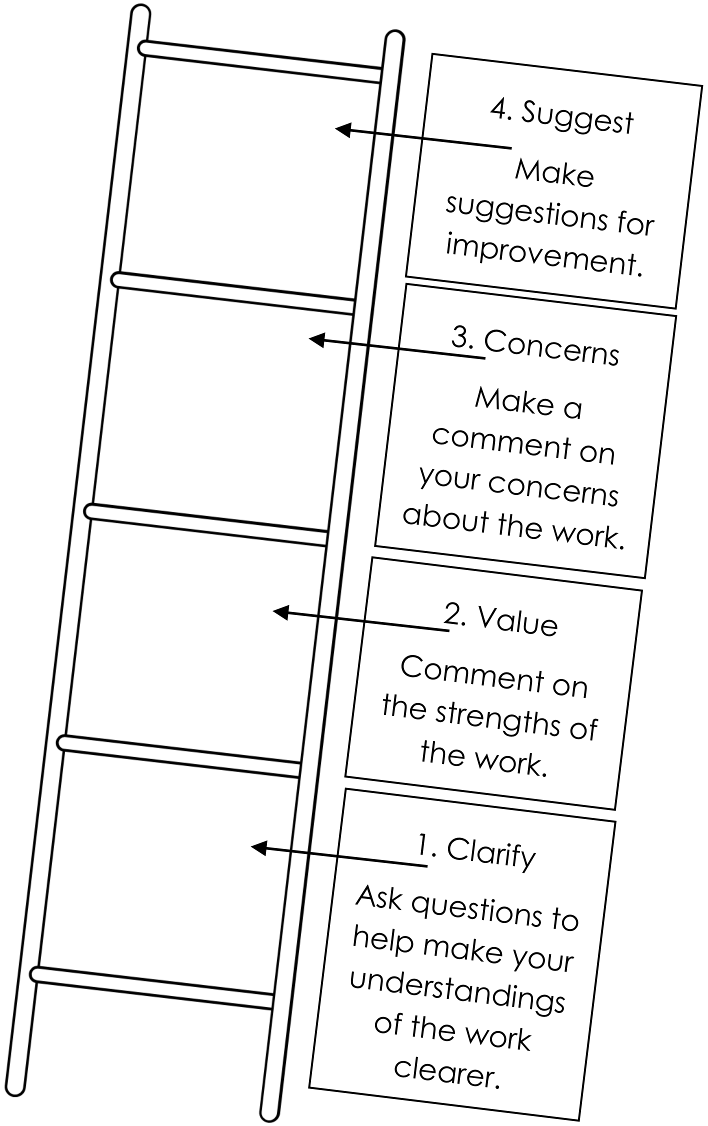
Things I would keep the same

Things I would change

Extra things I could do

Photographs or drawing

Appendix 13: Student activity sheet 4.2: Ladder of feedback



Suggest	
Concerns	
Value	
Clarify	

STEM Consortium

Appendix 14: Student activity sheet 4.3: Self-evaluation

Self-reflection

Photograph or drawing of solution

What did you create?	How do you feel about your creation?
 White hat	 Red hat
What do you like about your creation?	What could you have done better?
 Yellow hat	 Silver hat

What would you do differently?
 Green hat

Pixabay.com

Appendix 15: Teacher resource sheet 4.4: Student evaluation

Key: 1. Sometimes 2. Consistently 3. Independently and consistently	Student name												
Remains focused on tasks presented													
Completes set tasks to best of their ability													
Works independently without disrupting others													
Manages time effectively													
Cooperates effectively within the group													
Contributes to group discussions													
Shows respect and consideration for others													
Uses appropriate conflict resolution skills													
Actively seeks and uses feedback													

Appendix 16: Teacher resource sheet 4.5: 3 – 2 – 1 Reflection

3 – 2 – 1 Reflection			
Name	**3 things I learned**	**2 things I found interesting**	**1 thing I found difficult**

Notes