Curriculum resource module
Year 6
Off-the-grid living
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 and develop the general capabilities across Kindergarten to Year 12.

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.
Year 6 – Off-the-grid living

Overview

What is the context?

In a well-developed country such as Australia it is easy to access essential services such as electricity, gas, clean drinking water and sewerage. A lack of infrastructure in developing countries makes it more difficult for people to access energy and clean water.

The purpose of this module is to engage students in creating relatively simple, environmentally sustainable solutions that will generate energy and produce clean drinking water for living off-the-grid. Students design and build their solutions as examples of ways to provide these essential services in a developing country, in a developed country in an emergency, camping or for when these services are not available.

The module also aims to provoke students to reflect on their impact on the environment and raise their awareness about the appeal of sustainably living off-the-grid.

What is the problem?

How can we develop simple and sustainable solutions for living off-the-grid?

How does this module support integration of the STEM disciplines?

Science

Students build science understandings as they investigate the transfer and transformation of energy and research how wind, water and solar panels can be used to generate electricity (ACSSU097). Students consider whether energy sources are sustainable. Students plan and conduct investigations (ACSIS103, ACSIS104), and collect, represent and interpret data (ACSIS107).

Technologies

Students consider the role of technology in society and ways in which people address sustainability issues when designing products (ACTDEK019). Engineering principles and systems are examined when students create solutions following a design process (ACTDEK023) and investigate energy within systems (ACTDEK020).

The Design process guide is included as a resource to provide assistance to teachers in understanding the complete design process as developed in the Technologies syllabus.
Mathematics

Mathematics understandings and proficiencies are developed when students evaluate the rate of water desalination (ACMNA123), represent and interpret performance data (ACMSP147) from solar panels, examine shapes and units of measurement (ACMMG137) when designing a solar cooker and compare the performance of different solar cookers.

General capabilities

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

- Develop problem solving 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 approaches to solving the problems of off-the-grid living.
- 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.
- 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 and represent and communicate their solutions to an audience using digital technologies in Activity 4.

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
  This is an underlying part of all modules with every module based around solving an initial problem. It 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

Students collaboratively research off-the-grid living and sustainable ways to provide energy for heating, lighting and cooking, and drinkable water while living off-the-grid.

Off-the-grid living

Activity 2

INVESTIGATE

Students conduct investigations into the effectiveness of both solar panels, for producing electricity and, solar stills for producing drinking water.

Designing for off-the-grid

Activity 3

IMAGINE & CREATE

Students explore the design process and apply it to designing and making a solar cooker which will be tested in Activity 4.

Solar cooker design and construction

Activity 4

EVALUATE & COMMUNICATE

Students demonstrate, test and evaluate solar cookers and compare the performance of different solar cooker designs. They evaluate results and present their solution to an audience using multimedia.

Solar cooker demonstration and testing
Background

Expected learning  Students will be able to:

1. Define sustainability and sustainable living.
2. Describe sustainable methods of electricity generation including the use of solar panels.
3. Formulate a question, plan and conduct an investigation, collect and analyse data to measure the performance of a solar (photovoltaic) panel under different conditions.
4. Formulate a question, plan and conduct an investigation, collect and analyse data to measure the performance of a solar still in producing drinking water.
5. Convert units of measurement and calculate rates of electricity and distilled water.
6. Compare rates of water and electricity production to those required to meet domestic needs.
7. Using scientific principles, justify the choice of materials and shapes used in the design of the solar cooker.
8. Imagine and design a solar cooker and represent the design as an annotated diagram.
9. Working from their design, select appropriate materials and construction techniques to construct a prototype solar cooker.
10. Test and compare the effectiveness of their designs, evaluate the results and make judgments about the effectiveness of their design.

Vocabulary  This module uses subject-specific terminology.

The following list contains vocabulary that need to be developed, either before the module commences or as it is used.

absorb, amenities, condensation, conductor, consumption, desalination, energy, energy transfer, energy transformation, environmental footprint, evaporation, generate, heat, insulator, molecule, non-renewable resources, off-the-grid, parabolic shapes, photovoltaic, radiation, reflect, solar energy, solar panel, sustainable, temperature, utilities,

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.
**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:

- It is expected that students will be using the internet to complete this module and will need to be educated on internet safety including cyber bullying, privacy and protection.
- Exercise caution when cutting and joining materials.
- Exercise caution with the heat the cookers produce.
- Uncooked food should be used with caution.
- Sun safety will need to be considered.

**Enterprise skills**  
The Off-the-grid living module focusses on higher order skills with significant emphasis on expected learning from the general capabilities and consideration of what are considered to be Enterprise skills.

The Enterprise skills include: problem solving, communication skills, digital literacy, teamwork, financial literacy, creativity, critical thinking and presentation skills.

Further background on this is available from the Foundation for Young Australians. An example is the article The New Basics: Big data reveals the skills young people need for the New Work Order (Foundation for Young Australians, 2016) www.fya.org.au/wp-content/uploads/2016/04/The-New-Basics_Web_Final.pdf

This is the Foundation for Young Australians New Work Order research series. Six reports analysing how disruption to the world of work has significant implications for young Australians www.fya.org.au/our-research/.

**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, assessment opportunities will arise.

The *Curriculum links and learning opportunities* tables link expected learning to the activities and show content descriptions and standards from science, technologies and mathematics.

Evidence of learning from journalling, presentations and anecdotal notes 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 continua* but are not intended to be for assessment purposes.
### Activity 1: Off-the-grid living

**Activity focus**  
Students collaboratively research off-the-grid living and sustainable ways of providing energy and drinkable water.  
Students record their research findings and create a reflective journal to document their thinking.

**Background information**  
Off-the-grid living refers to being self-sufficient and not relying on public utilities for electricity, water, gas and sewerage. Successful off-the-grid living solutions achieve sustainability by reducing or eliminating the use of non-renewable resources.  
People in developed countries may choose to live off-the-grid to reduce their environmental footprint or because they live in a remote location. In developing countries, people may be forced to live off-the-grid as they are unable to afford, or have limited access to, utilities.  
There are a variety of ways of generating sources of energy off-the-grid such as wind generators, solar panels, and burning wood or dried manure to heat water and for cooking.  
Living off-the-grid can have positive impacts such as reducing consumption of non-renewable resources. There can also be negative effects such as having to work harder to keep systems sustainable (e.g., growing your own food or maintaining your own energy supplies).  
Understanding how a generator transforms the kinetic energy of moving wind or water into electrical energy, or how a solar panel harnesses the Sun’s energy, will help students consider what goes into their designs. See digital resources for more information on this.

**Instructional procedures**  
This activity is intended to be student-led through individual and collaborative research, brainstorming and reflection. Prompt questions and the placemat strategy are suggested scaffolds to support student inquiry. See *Teacher resource sheet 1.3: Cooperative learning – Placemat*.

In Activity 4, an authentic audience such as parents, canteen staff or a chef could be invited to observe the
testing of the cookers and to hear students’ explanations of their designs and how they work.

Expected learning

Students will be able to:
1. Define sustainability and sustainable living. (Science)
2. Describe sustainable methods of electricity generation including the use of solar panels. (Science)

Equipment required

For the students:
Access to internet and library
Paper for Placemat activity
Devices

Preparation

Preload the webpage links in Digital resources to a common drive to ensure all students can access material to complete the research questions.

Activity parts

Part 1: What does it mean to be ‘off-the-grid’?
Working in groups, students research and use a visual display such as a storyboard to present to the class their understanding of the following aspects of sustainability:

- What does off-the-grid living mean?
- Why do people live off-the-grid?
- What makes a resource sustainable?
- What are sustainable methods of generating electricity and how do they work?

Students can use the placemat strategy, see Teacher resource sheet 1.3: Cooperative learning – Placemat when researching. See Digital Resources for suggested links for research.

Part 2: Power cut

As a class, brainstorm the impact of an electricity outage for a week and strategies that would be adopted. Prompt students to come up with their own ideas.

Students should consider that fresh water supply, sewerage removal and use of electricity for power or cooking was not available.

Suggested example: An electricity outage that affected a whole suburb for a week would stop the pumps that take
sewage away to the water treatment plant, the pumps needed to pressurise the water supply, and the supply of electricity for lighting and cooking.

- What strategies would you adopt to cope with this crisis?

**Part 3: Reflection and journalling**

Students review their definitions of sustainability and reflect on their dependence on utilities in their learning journals or online blogs. See *Student journal* for elaboration.

**Resource sheets**

- Teacher resource sheet 1.3: Cooperative learning – Placemat

**Digital resources**

- eSafety classroom resources (Office of the eSafety Commissioner, 2018)
  esafety.gov.au/education-resources/classroom-resources

- Primary Connections – Essential Energy (Australian Academy of Science, 2018)
  primaryconnections.org.au/shop/2PC605-BK

- Richgro Bioenergy Plant, Jandakot, Western Australia (Waste Management Review, 2016)


- How Wind Turbines Generate Electricity (Andy Dunau, 2009)
 youtu.be/0Kx3qj_oRCc
**Activity 2: Designing for off-the-grid**

**Activity focus**
Students conduct investigations into the effectiveness of both solar panels, for producing electricity and, solar stills for producing drinking water.

**Background information**
Photovoltaic (PV) cells transform light energy into electrical energy. Materials such as PV in a solar cell absorb photons of light and release electrons. These free electrons flow in an electric current when the solar panel is connected in an electric circuit. Solar panels generate direct current (DC) electricity like a battery. An inverter can be used to convert direct current to alternating current (AC) like the electricity supplied from a power station. The electrical output from a set of 10 solar panels can be as high as 3000 watts (or 3kW). This is enough to boil a kettle and run a toaster at the same time.

One way fresh water can be obtained from salty water is by evaporation. Sunlight can provide energy to water molecules so that they move faster and escape from the surface of the liquid to become water vapour (a gas), leaving the salt molecules behind. The molecules of water can then move freely. If the water vapour in the air reaches a cold surface, the water molecules move more slowly, form tiny droplets and join together to form pure water suitable for drinking. We see these droplets on cold windows as condensation.

**Expected learning**
Students will be able to:

1. Formulate a question, plan and conduct an investigation, collect and analyse data to measure the performance of a solar still. (Science)

2. Formulate a question, plan and conduct an investigation, collect and analyse data to measure the performance of a solar still in producing drinking water. (Science)

3. Convert units of measurement and calculate rates of electricity and amount of desalinated water collected. (Mathematics)
4. Compare rates of electricity and amount of desalinated water collected to those for domestic requirements. (Mathematics)

<table>
<thead>
<tr>
<th>Equipment required</th>
<th>For the class:</th>
</tr>
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<tbody>
<tr>
<td></td>
<td><em>Teacher resource sheet 2.3: Water desalination experiment</em></td>
</tr>
<tr>
<td></td>
<td><em>Teacher resource sheet 2.1: Solar panel experiment</em> Kits will need to be purchased or borrowed from a high school.</td>
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<tr>
<th>For the students:</th>
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<tr>
<td><em>Student activity sheet 2.4: Water desalination experiment</em></td>
</tr>
<tr>
<td><em>Student activity sheet 2.2: Solar panel experiment</em></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Preparation</th>
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<tbody>
<tr>
<td>Teachers should familiarise themselves with the requirements of the experiments and supply the materials detailed in the resource sheets.</td>
</tr>
<tr>
<td>The links in the <em>Digital resources</em> can be used to develop student understandings about energy.</td>
</tr>
<tr>
<td>Organise small solar panel kits (see <em>Digital resources</em>) from hobby engineering stores (such as Jaycar Electronics, or Scientifíc.com.au) or borrowed from high schools.</td>
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<tr>
<th>Activity parts</th>
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<tbody>
<tr>
<td><strong>Part 1: What could we do?</strong></td>
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<tr>
<td>Students work in small groups of three or four for the following ‘thought experiments’.</td>
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<tr>
<td>Discuss whether the students have solar panels at home and how they work.</td>
</tr>
<tr>
<td>Prior to using the resource sheets for the experiments, hold a brainstorm on ways to provide electricity and clean drinking water following a natural disaster in an isolated area of Western Australia.</td>
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<tr>
<td>Prompt questions can include:</td>
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<tr>
<td>- Could solar panels generate enough electricity to power light bulbs or charge mobile phones?</td>
</tr>
<tr>
<td>- How much water would we need each day for survival?</td>
</tr>
<tr>
<td>- How could you produce enough clean water to meet your needs?</td>
</tr>
</tbody>
</table>
| Following the brainstorm groups work to complete the
experiments that support the brainstormed solutions.

Students formulate a question for investigation and plan the experiments and data collections. See Teacher resource sheet 2.1: Solar panel experiment and Student activity sheet 2.2: Solar panel experiment. Alternatively students

Prompt student thinking using questioning:

- How much electrical energy can be produced by a solar panel? How would we measure this?
- Where should the solar panel be placed to maximise electricity generation?
- Is the rate at which electricity is produced sufficient for our needs?
- How much drinking water can be produced by a simple solar still? How fast can it produce drinking water and will this be sufficient for our needs?

Students record their findings in their reflective journals or online blogs.

This is an excellent opportunity for students to develop and plan their own investigations on their choice of off-grid living resources. Peer facilitated, inquiry based learning is encouraged as best practice, however, the following parts of this activity are scaffolded for teachers who prefer this approach.

Part 2: Testing a solar panel

Set up a solar panel and take measurements with a multimeter to calculate the power output of the panel. Refer to Teacher resource sheet 2.1: Solar panel experiment and Student activity sheet 2.2: Solar panel experiment for instructions. Place the solar panel in full sun, partial shade and full shade, record the voltage and current readings from these, and calculate the rate at which electrical energy is produced. Compare the electrical energy produced with that required to power domestic appliances such as a kettle.

Part 3: Making and testing a solar still

Teacher resource sheet 2.3: Water desalination experiment and Student activity sheet 2.4: Water desalination experiment explain how to set up a solar still which can be used to produce fresh drinking water from salty or contaminated water.
Different groups could vary the design of their solar still by using different sized containers or substituting black plastic for the transparent cling wrap. Students consider how the processes of evaporation and condensation of water enable the still to produce fresh water.

Students measure the quantity of water collected during the experiment and calculate the rate of water production in mL/min. They convert this to L/h, an opportunity to practise converting units of measurement.

**Part 4: Reviewing the data**

Review the results from the two experiments and consider the size of solar panels and stills that would be needed to supply useful quantities of electricity and water. Discussion questions could include:

- Where did the solar panel work best? Why?
- How do solar panels work? Where did the electrical energy come from?
- How much electrical energy was produced? Was this enough to boil a kettle?
- How could you increase the power output of solar panels?
- How did the solar still make drinking water?
- What happened to the salt?
- How much water could your still make in an hour? Is this enough to supply drinking water?
- How could you design a still that would produce a greater quantity of water?

Discuss the principles of solar panels converting light energy to electrical energy and the concepts of evaporation and
condensation with the students.

**Part 5: Journalling**

Students document their thinking and reflections on the activities in their journals or online blogs.

### Resource sheets

- **Teacher resource sheet 2.1: Solar panel experiment**
- **Student activity sheet 2.2: Solar panel experiment**
- **Teacher resource sheet 2.3: Water desalination experiment**
- **Student activity sheet 2.4: Water desalination experiment**

### Digital resources

- Energy Resources: What power can you get from a solar panel - practical activity (Education Services Australia, 2017)
  

- Putting STEM into Science - Innovative STEM teaching resources (STELR, 2016)
  
  [www.stelr.org.au](http://www.stelr.org.au)

- Solar Energy – Electricity (STELR, 2016)
  

  
Activity 3: Solar cooker design and construction

**Activity focus**

In this activity students explore the design process and apply it to designing and making a solar cooker.

**Background information**

The focus of the module from this point is on solar cookers. It is important to note that there is scope for students to design and build other off-grid solutions (i.e., solar phone chargers) while maintaining the structure of the activity.

Solar cookers involve the transfer and transformation of energy.

In parabolic cookers, light energy strikes the surfaces, where it is reflected and concentrated at the focal point of the cooker and transformed into heat energy. Light emitted by the Sun transfers a lot of energy. When it strikes a solid or liquid, most of this energy causes the molecules in that matter to vibrate and this activity generates heat. In this way, light energy is transformed into heat energy.

Dark surfaces get very hot in sunlight because they absorb light energy, while light and shiny surfaces reflect light. Dark coloured cooking pots work best in a solar cooker because they absorb light energy and convert it to heat energy.

In designing their solar cookers students are attempting to maximise the efficiency of their cookers. There are three main designs: box, panel and parabolic cookers.


Parabolic designs involve using reflective materials formed into shapes that reflect and focus the light energy onto the cooking pot.

Box cookers are insulated boxes that capture the energy that shines into it. The glass or plastic top creates a kind of greenhouse effect in the box. One or more reflective surfaces are attached to the sides of the box to allow more sunlight to enter through the glass top.

Panel type solar cookers consist of a number of reflecting panels. The focus of the panels is the pan. To prevent the pan from losing its heat, the pan is put in a transparent and heat-resistant plastic bag.
The different materials used to construct a solar cooker need to have a range of properties that enable: reflection and absorption of light and heat energy where appropriate as well as the conduction and insulation of heat energy where necessary. The sides of the cooker need to be made of reflective material (e.g., aluminium foil), and the cooking pot needs to be made of a material that absorbs heat (i.e., dark colour) and conducts heat to the food (i.e., metal). The outer surfaces of the cooker could be covered with an insulating material (e.g., cardboard) to stop heat being lost to the air.

Solar cookers can be very efficient, transforming up to 80% of light energy into heat energy. They can generate high temperatures which could pose a safety risk.

### Instructional procedures

To better manage the design and construction of solar cookers, the following constraints are suggested:

- It must be constructed from low or no-cost material readily available or repurposed from the household.
- It must be of simple design and size that is able to be constructed within the classroom with basic hand tools.
- The final design must be discussed with the teacher before the production phase to ensure the project has the best chance of being successful.
- Additional resources identified by students must be able to be acquired in a timely manner.

To better manage available resources, solar cookers could be designed and built by groups of three or four students using assigned roles.

The design process needs to consider the shape of the cooker, the materials to be used for each part of the cooker, and how each part will be cut to shape and joined to other parts.

For comparison of performance in Activity 4, it would be ideal if there is at least one variation in the types of design. A key component of students’ reflection is to discuss whether the elements of design (shape, size and material properties) were a factor in the performance.

The [Design process guide](#) outlines how the design process is...
cyclic and often involves evaluating and redesigning.

Redesigning can be a formal process or it can be performed ‘on the run’ during any stage of the process.

**Expected learning**

Students will be able to:

1. Justify the choice of materials and shapes used in the design of a solar cooker using scientific principles. (Science)
2. Imagine, design and represent a design for a solar cooker as an annotated diagram. (Technologies)
3. Working from their design, select appropriate materials and construction techniques to construct a solar cooker. (Technologies)

**Equipment required**

For the students:

A range of household materials including but not limited to:

- cardboard boxes in a variety of sizes and styles
- aluminium foil
- newspaper
- tools such as scissors, tape, glue, stapler

**Preparation**

Teachers should familiarise themselves with the *Design process guide*.

**Activity parts**

**Part 1: Overview of the design process and parameters**

Review the design process with students referring to the *Design process guide*.

**Research**

Students research and review the designs for solar cookers. This research should include developing an explanation of how solar cookers work. Key processes to be incorporated in the explanation should include light energy, reflection and heat energy. Refer to *Digital resources* for further information and review to determine which resources will be useful for your students.

**Establishing a project plan**

This step involves forming groups, assigning group roles, revealing the materials available, and prescribing the time that will be made available for designing and constructing. See *Teacher resource sheet 1.1: Cooperative learning – Roles*. 
Part 2: Designing the solar cooker

Students work in groups to imagine and create their design and then represent their design as an annotated drawing.

Key design decisions relate to the shape of the cooker, the materials to be used for each part and how each part will be cut to shape and joined to other parts.

The drawing needs to include annotations that justify the choice of materials for each part of the cooker.

The final group design is to be discussed with the teacher prior to moving to the production phase. This encourages justification of design choices, embedding the design process and allowing opportunity for changes to be made prior to moving to the next phase.

Part 3: Constructing the prototype solar cookers

Once each group has decided on the design, choice of materials and joining techniques, the teacher should review safety precautions associated with cutting and joining materials with the whole class.

Provide sufficient time for students to construct their cooker providing coaching on construction techniques and prompting reflection by asking:

- Why are you using that material?
- Why are you joining materials that way?
- Which parts will get hot? Will they hold together when they get hot?
- What are you struggling with? How will you fix that problem?

Part 4: Review progress and journalling

Ask student groups to reflect on the construction phase:

- What went well?
- What was difficult?
- How did you fix that?

Students record their reflections in their journals or on their blogs.
<table>
<thead>
<tr>
<th>Resource sheets</th>
<th>Design process guide</th>
</tr>
</thead>
</table>
| Digital resources | Finding the Focal Point (WGBH Educational Foundation)  
www.pbs.org/wgbh/nova/education/activities/3406_solar_03.html |
almostunschoolers.blogspot.com.au/2015/05/parabolic-solar-shoebox-cooker-math-you.html?_sm_au_=iqV5gZMmj2fHfHJB |
| | Science Projects on Solar Cooking an Egg by the Sun (Sciencing, 2017)  
| Solar cooker design ideas | 6 Homemade Solar Oven Projects for Kids (Sunshine On My Shoulder, 2018)  
sunshineonmyshoulder.com/6-homemade-solar-oven-projects-for-kids |
| | Make Sun S’mores! (NASA Climate Kids, 2017)  
climatekids.nasa.gov/smore |
| | How to build a solar oven (Home Science Tools, 2018)  
www.homesciencetools.com/a/build-a-solar-oven-project |
**Activity 4: Solar cooker demonstration and testing**

**Activity focus**

Students demonstrate, test and evaluate their solar cookers and compare the performance of different solar cooker designs. Students share their learning journey with an authentic audience.

<table>
<thead>
<tr>
<th>Background information</th>
</tr>
</thead>
<tbody>
<tr>
<td>When comparing the performance of the solar cookers the testing should be fair. Fair testing may include ensuring cookers are tested at the same time of day, are exposed to the same environmental conditions, and that measurements are taken with the same procedures and instrument.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional procedures</th>
</tr>
</thead>
</table>
| This activity provides an opportunity for students to compare the efficiency of their solar cookers, and to demonstrate their effectiveness to an authentic audience. Parents, canteen staff or a chef could be invited to hear students’ explanations of their designs and how they work. The presentations provide a rich opportunity for assessing students’ understanding of the science, technology and mathematics principles and processes as well as cross-curriculum assessment of literacy, speaking and listening. Students continue to work in their groups. They will need support and scaffolding to help them prepare for their presentation. Students may need information about effective presentation skills such as voice clarity, projection, volume, pitch and tone. Time constraints should be set for presentations and all students should have an opportunity to speak. 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. See Teacher resource sheet 1.1: Cooperative learning – Roles. Presentation options include creating a comic strip, eBook, poster in Pages, Keynote or PowerPoint or simple iMovie (or similar), which can then be shared through a digital platform such as Connect, Seesaw or Class Dojo, added to a class blog, or shared on the interactive whiteboard.
Students may require explicit instruction when using these apps.

If digital technology is not accessible, students could share their project using a traditional poster or recount.

To enable the completion of the design process students should be given time to make improvements to their work based on feedback received from the presentations. This could be provided in groups or as a private reflection in learning journals. Time should be taken to discuss how to give constructive feedback and how to take feedback positively.

Year 6 students will have had prior experience of planning an investigation involving fair testing and could be guided through an investigation planning template [Student activity sheet 2.5: Solar cooker testing].

Possible methods of testing the efficiency of the cookers include:

- The increase in temperature of 100 millilitre of water at 15 minute intervals
- The time taken for 10 grams of popcorn to pop
- The time taken for food to visibly change.

<table>
<thead>
<tr>
<th>Expected learning</th>
<th>Students will be able to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Test and compare the effectiveness of their designs, evaluate the results and make judgments on the effectiveness of their design based on performance data. (Science)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment required</th>
<th>For the class:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Materials to construct solar cookers as identified in the design process</td>
</tr>
<tr>
<td></td>
<td>Scissors, glue, string</td>
</tr>
<tr>
<td></td>
<td>Digital camera or device</td>
</tr>
<tr>
<td></td>
<td>Multimedia specific to students’ presentation requirements</td>
</tr>
</tbody>
</table>

| For the students: | |
|--------------------| |
|                    | A temperature gun or infrared thermometer |
|                    | Appropriate food for placing in the solar cookers |
Digital devices loaded with appropriate apps for multimedia presentations

**Preparation**

Check the weather forecast and plan to conduct the testing of solar cookers on a bright sunny day. Source suitable thermometers.

Source appropriate food.

Aluminium soft drink cans cut off to form a short ‘cup’ shape about 5 cm high would be suitable cooking pots. A parent may be able to do this. Ensure the cut surfaces are free from sharp edges.

Ensure technology and media are available.

It is assumed that presentations will be made by groups, which means the presentations may have to be scheduled across two separate sessions.

How long will the presentations be? Suggest five minutes plus two minutes for questions and two minutes swap over between groups (ie nine to ten minutes per group).

Who will speak? One person might introduce the presentation, another give the presentation, and a third answer any questions.

Information on developing presentation skills and teacher resources for scaffolding student learning can be sourced from the Phys.org article in the Digital resources section.

**Activity parts**

**Part 1: Introduction**

Introduce the purpose of the activity which is to test the effectiveness of the solar cookers and demonstrate their performance to the invited guests.

**Part 2: Planning a fair test of the cookers**

Guide students through the planning of the fair test of the solar cookers using an investigation planning template (See Student activity sheet 2.5: Solar cooker testing). Focus on the question, the prediction, how the performance of the solar cookers will be measured, the control of variables and how the results will be recorded.

Before testing the cookers, students could investigate variances in the heat produced at different areas of the cookers using a heat probe or data logger. To visualise this, a number of marshmallows or chocolate dots could be
placed in the cookers for students to observe and compare the rate of melting. Students should be given the opportunity to revise their designs before moving to Part 3.

**Part 3: Students test the cookers**

Students prepare their cookers and perform the tests as agreed in the planning process. Students record their results on the investigation planning template [Student activity sheet 2.5: Solar cooker testing](#).

**Part 4: Collating the results**

Prepare a table on the interactive whiteboard or similar into which the results from each group can be recorded. Students copy these results onto their investigation planner. Alternatively, students could record data in a collaborative document such as [Google Sheets](#).

The results are discussed to engage students in reasoning about design features:

- Which cookers performed the best? How do you know?
- Which cookers were not successful? How do you know?
- Were the tests fair? What could have been improved?
- What design features made the best cookers work well? Why? How? ... Because etc

**Part 5: Students complete their reports and reflections**

Students complete their investigation reports by explaining their results of their cooker and comparing it with others. They explain why certain designs were effective and evaluate their investigation and design.

**Part 6: Deciding on content**

Students decide on the content of their presentation by asking:

- Why is there a need to develop off-grid living solutions?
- What were we trying to achieve in our solution?
- What decisions did we make as we developed our solution?
- How did our mathematics and science knowledge help us develop our ideas?
Part 7: Preparing media

Students decide on the media to be used for their presentation. Options include:

- Talk using the model or a poster.
- Speak to slides which include photos of the model.

Digital options include comic strips, eBook, poster in Pages, Keynote or PowerPoint or simple iMovie (or similar), which can then be shared through a digital platform such as Connect, Seesaw or Class Dojo, or added to a class blog.

Part 8: Creating and delivering presentations

Students work in their groups to prepare the presentations. Timing and speaking skills will need to be discussed as well as content for the slides (i.e., slides should not be text heavy).

Teacher resources for developing presentation skills in students can be found in the Phys.org article in the Digital resources section. Students will need help developing the skills needed for pitching their ideas.

Once students have finished, they present their work to an authentic audience. This also presents an opportunity to develop community partnerships.

Part 9: Completing the design

Using peer feedback students apply changes to their design solution.

Part 10: Reflection

Students reflect on their learning journey, recording thoughts on their blogs or in their learning journals.

Resource sheets


Comic Maker HD
bugunsoft.com/comicmakerhd

iBooks Author
www.apple.com/au/ibooks-author

Book Creator
bookcreator.com

iMovie
itunes.apple.com/au/app/imovie/id377298193?mt=8

Pages
itunes.apple.com/au/app/pages/id361309726?mt=8

Keynote
itunes.apple.com/au/app/keynote/id361285480?mt=8

Seesaw Digital Portfolio
web.seesaw.me

Class Dojo
www.classdojo.com

eBook
www.ebooks.com

Scratch
www.scratch.mit.edu
splash.abc.net.au/home#!/digibook/2427023/introduction-to-scratch

Kids coached to pitch world-changing ideas (Phys.org, 2014)
Appendix 1: Curriculum links and learning opportunities

The Off-the-grid living module provides opportunities for developing students’ knowledge and understandings in science, technologies and mathematics. The tables below show how this module aligns to the content of the Western Australian Curriculum and can be used by teachers for planning and monitoring. The evidence pointers in this table are not assessment criteria. They are indicators which, when used collectively, represent the pitch for each grade standard for reporting purposes. They describe some of the things students may do at each standard but will vary depending on the specific tasks selected by the teacher. They should not be used as a checklist. Grade judgements should occur at the conclusion of a period of time (usually a semester or year) using a number of pieces of work.

Science:

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Expected Learning</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excellent achievement</strong></td>
<td>The student demonstrates excellent achievement of what is expected for this year level</td>
<td>Describes methods of electricity generation and how electric circuits transfer and transform energy in solar panels.</td>
<td>Activities 1, 2, 3</td>
</tr>
<tr>
<td><strong>High achievement</strong></td>
<td>The student demonstrates high achievement of what is expected for this year level</td>
<td>Analyses the key requirements for the transfer of electrical energy in complex circuits and describes energy transformations in each part of the circuit.</td>
<td></td>
</tr>
<tr>
<td><strong>Satisfactory achievement</strong></td>
<td>The student demonstrates satisfactory achievement of what is expected for this year level</td>
<td>Identifies the key requirements for a simple electric circuit to enable the transfer and transformation of electrical energy.</td>
<td></td>
</tr>
<tr>
<td><strong>Limited achievement</strong></td>
<td>The student demonstrates limited achievement of what is expected for this year level</td>
<td>Identifies some requirements for the transfer of electrical energy.</td>
<td></td>
</tr>
<tr>
<td><strong>Very low achievement</strong></td>
<td>The student demonstrates very low achievement of what is expected for this year level</td>
<td>Does not identify requirements.</td>
<td></td>
</tr>
</tbody>
</table>

Science understanding

Physical sciences

- **Content description:** Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)
- **Expected learning:** Describes methods of electricity generation and how electric circuits transfer and transform energy in solar panels.
- **Activities:** Activities 1, 2, 3

- Analyses the key requirements for the transfer of electrical energy in complex circuits and describes energy transformations in each part of the circuit.
- Analyses the key requirements for the transfer of electrical energy in a simple electric circuit and describes energy transformations in each part of the circuit.
- Identifies the key requirements for a simple electric circuit to enable the transfer and transformation of electrical energy.
- Identifies some requirements for the transfer of electrical energy.
- Identifies limited energy.

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<table>
<thead>
<tr>
<th>Planning and conducting</th>
<th>Describes in detail a process showing how different energy sources can be transformed to generate electricity.</th>
<th>Describes a process showing how different energy sources can be transformed to generate electricity.</th>
<th>Describes how energy sources can be transformed to generate electricity.</th>
<th>sources that can be transformed to generate electricity.</th>
</tr>
</thead>
</table>

### Science inquiry skills

<table>
<thead>
<tr>
<th>Planning and conducting</th>
<th>Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSI103)</th>
<th>Investigates the performance of a solar still in producing drinking water and the performance of a solar (photovoltaic) panel under different conditions.</th>
<th>Activity 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plans and conducts well-structured investigations into relationships between variables, specifying in detail how variables will be changed and measured.</td>
<td>Conducts investigations into relationships between variables, specifying how variables will be changed and measured.</td>
<td>Follows investigations into simple relationships between variables.</td>
<td>With guidance, follows procedures for a simple investigation.</td>
</tr>
<tr>
<td>Decide variables to be changed and measured in fair tests, and observe, measure and record data with accuracy using digital technologies as appropriate (ACSI104)</td>
<td>Collect and analyse data to measure the performance of a solar still in distilling water and measure the performance of a solar (photovoltaic) panel under different conditions.</td>
<td>Activity 2</td>
<td></td>
</tr>
<tr>
<td>Accurately collects, records and analyses data.</td>
<td>Accurately takes measurements and records data as required by experiment procedures.</td>
<td>Independently participates in taking some measurements and records some data.</td>
<td>With guidance, participates in taking some measurements and records some data.</td>
</tr>
<tr>
<td>Does not take measurements or record data.</td>
<td>Does not follow investigation procedures.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Further information about assessment and reporting of Science can be found at: k10outline.scsa.wa.edu.au/home/p-10-curriculum/curriculum-browser/science-v8/overview/implications-for-teaching,-assessment-and-reporting
### Technologies:

#### Design and Technologies: Knowledge and understanding

<table>
<thead>
<tr>
<th>Technologies and society</th>
<th>Content description:</th>
<th>Expected learning:</th>
<th>Activities:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excellent achievement</strong></td>
<td>How people address competing considerations, including sustainability when designing products, services and environments for current and future use (ACTDEK019)</td>
<td>Makes design decisions based on sustainability.</td>
<td>Activities 2 &amp; 3</td>
</tr>
<tr>
<td><strong>High achievement</strong></td>
<td>Explains the ways people address and overcome competing considerations, including sustainability, when designing products, services and environments for current and future use, including a range of examples.</td>
<td>Describes how people address and overcome competing considerations, including sustainability, when designing products, services and environments for current and future use, including a range of examples.</td>
<td></td>
</tr>
<tr>
<td><strong>Satisfactory achievement</strong></td>
<td>Identifies how people address and overcome competing considerations, including sustainability, when designing products, services and environments for current and future use.</td>
<td>States that electrical energy or forces can control movement, sound or light in a product or system.</td>
<td></td>
</tr>
<tr>
<td><strong>Limited achievement</strong></td>
<td>Lists some simple ways that people address competing considerations when designing a product, service and/or environment for current and/or future use.</td>
<td>Does not make up a list.</td>
<td></td>
</tr>
<tr>
<td><strong>Very low achievement</strong></td>
<td>Does not make a statement.</td>
<td>Takes the features of an electrical system.</td>
<td>Activities 1 &amp; 2</td>
</tr>
</tbody>
</table>

#### Engineering principles and systems

<table>
<thead>
<tr>
<th>Technologies and society</th>
<th>Content description:</th>
<th>Expected learning:</th>
<th>Activities:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excellent achievement</strong></td>
<td>Explains ways electrical energy and forces can control movement, sound or light in a product or system.</td>
<td>Connects ways electrical energy and forces can control movement, sound or light in a product or system.</td>
<td></td>
</tr>
<tr>
<td><strong>High achievement</strong></td>
<td>Describes ways electrical energy and forces can control movement, sound or light in a product or system.</td>
<td>States that electrical energy or forces can control movement, sound or light in a product or system.</td>
<td></td>
</tr>
<tr>
<td><strong>Satisfactory achievement</strong></td>
<td>Investigates the features of an electrical system.</td>
<td>Takes the features of an electrical system.</td>
<td></td>
</tr>
<tr>
<td><strong>Limited achievement</strong></td>
<td>Does not make a statement.</td>
<td>Investigates the features of an electrical system.</td>
<td>Activities 1 &amp; 2</td>
</tr>
<tr>
<td><strong>Very low achievement</strong></td>
<td>Does not make a statement.</td>
<td>Investigates the features of an electrical system.</td>
<td>Activities 1 &amp; 2</td>
</tr>
</tbody>
</table>
### Materials and technologies specialisations

<table>
<thead>
<tr>
<th>Characteristics, properties and safe practice of a range of materials, systems, tools and equipment; and evaluate the suitability of their use (ACTDEK023)</th>
<th>Working from their design, select appropriate materials and construction techniques to construct a solar cooker. Using science principles, justify the choice of materials and shapes used in the design of a solar cooker.</th>
<th>Activity 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considers and evaluates suitability of use when examining characteristics, properties and safe handling practices of a range of materials, systems, tools and equipment.</td>
<td>Considers and evaluates suitability of use when defining characteristics, properties and safe handling practices of a range of materials, systems, tools and equipment.</td>
<td>Considers suitability of use when defining characteristics, properties and safe handling practices of a range of materials, systems, tools and equipment.</td>
</tr>
</tbody>
</table>

### Design and Technologies: Processes and production skills

<table>
<thead>
<tr>
<th>Designing</th>
<th>Design, modify, follow and represent both diagrammatically, and in written text, alternative solutions using a range of techniques, appropriate technical terms and technology</th>
<th>Imagine, design and represent a design for a solar cooker as an annotated diagram.</th>
<th>Activity 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develops and explains alternative solutions by consistently designing, modifying, representing and following, both diagrammatically and in written text, using a range of relevant appropriate technical terms, technologies and appropriate techniques.</td>
<td>Develops and explains alternative solutions by designing, modifying, representing and following, both diagrammatically and in written text, using a range of relevant appropriate technical terms, technologies and techniques.</td>
<td>Develops alternative solutions by designing, modifying, representing and following, both diagrammatically and in written text, using a range of appropriate technical terms, technologies and techniques.</td>
<td>Designs and follows diagrams and written text; however, only partially develops alternative solutions using familiar techniques, appropriate technical terms and/or technology.</td>
</tr>
</tbody>
</table>

Further information about ways of assessing Technologies can be found at: k10outline.scsa.wa.edu.au/home/p-10-curriculum/curriculum-browser/technologies/technologies-overview/ways-of-assessing
### Mathematics:

<table>
<thead>
<tr>
<th></th>
<th>Excellent achievement</th>
<th>High achievement</th>
<th>Satisfactory achievement</th>
<th>Limited achievement</th>
<th>Very low achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The student demonstrates <strong>excellent achievement</strong> of what is expected for this year level</td>
<td>The student demonstrates <strong>high achievement</strong> of what is expected for this year level</td>
<td>The student demonstrates <strong>satisfactory achievement</strong> of what is expected for this year level</td>
<td>The student demonstrates <strong>limited achievement</strong> of what is expected for this year level</td>
<td>The student demonstrates <strong>very low achievement</strong> of what is expected for this year level</td>
</tr>
</tbody>
</table>

### Number and algebra

<table>
<thead>
<tr>
<th><strong>Number and place value</strong></th>
<th><strong>Content description:</strong></th>
<th><strong>Expected learning:</strong></th>
<th><strong>Activities:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers (ACMNA123)</td>
<td>Convert units of measurement and calculate rates of electricity and water production.</td>
<td>Activity 2</td>
<td></td>
</tr>
<tr>
<td>Applies efficient mental and written strategies to perform more complex calculations involving all four operations and justifies answers.</td>
<td>Applies a range of mental and written strategies to solve problems involving all four operations with whole numbers, and explains the chosen strategy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solves problems involving all four operations with whole numbers.</td>
<td>Solves problems involving all four operations with some accuracy.</td>
<td>Does not solve problems.</td>
</tr>
</tbody>
</table>
### Measurement and geometry

<table>
<thead>
<tr>
<th><strong>Using units of measurement</strong></th>
<th><strong>Solve problems involving the comparison of lengths and areas using appropriate units (ACMMG137)</strong></th>
<th><strong>Compare rates of water and electricity production to those required to meet domestic requirements.</strong></th>
<th><strong>Activity 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appplies the connection between capacity and volume to solve problems and represents the connection using units.</strong></td>
<td>Makes connections between capacity and volume and applies this to solve problems.</td>
<td>Makes connections between capacity and volume and represents this connection in at least one way.</td>
<td><strong>Recognises a connection between capacity and volume.</strong></td>
</tr>
<tr>
<td><strong>Does not recognize the connection.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Statistics and probability

<table>
<thead>
<tr>
<th><strong>Data representation and interpretation</strong></th>
<th><strong>Interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables (ACMSP147)</strong></th>
<th><strong>Record progressive measurements of the temperature in a side-by-side table and interpret and compare changes to the food or other points of interest.</strong></th>
<th><strong>Activity 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interprets and evaluates two categorical data displays and justifies most appropriate display for the data.</strong></td>
<td>Interprets and compares data displayed in a variety of ways for two categorical variables.</td>
<td>Interprets and compares data displayed for two categorical variables.</td>
<td><strong>Compares data displayed for two categorical variables.</strong></td>
</tr>
<tr>
<td><strong>Does not compare the data.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix 1B: Mathematics proficiency strands

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

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.
Appendix 1C: Mathematics in the modules

Each Curriculum Resource Module within the STEM Learning Project supports integration of the STEM disciplines. In terms of content, this is detailed within the module Overview.

With reference to mathematics, the problems encountered in each module provide opportunities that are complementary to normal lessons for developing higher order capabilities in the discipline. These capabilities are based on particular content, but are higher order mathematical thinking processes such as Understanding, Fluency, Problem-solving and Reasoning as outlined in the Mathematics proficiencies of the Australian Curriculum.

- For development of the Understanding proficiency, there is a focus on the transference of mathematical concepts to new situations, interpreting mathematical information and applying familiar knowledge to develop new ideas.
- For development of the Fluency proficiency, students are given the opportunity to choose their own procedures and carry these out flexibly to suit the requirements of the particular problem being solved. They are also encouraged to choose appropriate methods and approximations in numerical solutions according to the accuracy required.
- For development of the Problem-solving proficiency, the opportunity to make choices, interpret, formulate, model and investigate problem situations is built in to each module. Students are required to use mathematics to represent unfamiliar and meaningful situations and apply their existing strategies to seek solutions.
- For development of the Reasoning proficiency, the communication of the solution requires students to justify strategies used and conclusions reached. This often involves transfer of learning from known contexts to new contexts.

The four activities in each module blend this development of higher order mathematics with science and technology learning, while focussing on developing STEM capabilities.

Student activities sheets are a part of many of the modules. These activities are not designed primarily to facilitate the direct learning of content, although some are included as review of particular content points when that is required. The primary purpose of these activities is to extend the development of the proficiencies as detailed above. Learned skills are applied to new real world contexts, mathematical information must be interpreted, and problems must be solved by choosing appropriate skills and understandings to apply to the tasks given. Basing these activities around the real world problem being solved also increases the level of motivation towards the mathematics learned.

Teachers need to be cognisant of the underlying purpose of these Student activity sheets, so that the correct focus and expectations are in place as students complete this part of the learning in the module.
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.

**ICT capability learning continuum**

<table>
<thead>
<tr>
<th>Sub-element</th>
<th>Typically by the end of Year 4</th>
<th>Typically by the end of Year 6</th>
<th>Typically by the end of Year 8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Create with ICT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Generate ideas, plans and processes</strong></td>
<td>use ICT to generate ideas and plan solutions</td>
<td>use ICT effectively to record ideas, represent thinking and plan solutions</td>
<td>use appropriate ICT to collaboratively generate ideas and develop plans</td>
</tr>
<tr>
<td><strong>Create with ICT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Generate solutions to challenges and learning area tasks</strong></td>
<td>create and modify simple digital solutions, creative outputs or data representation/transformation for particular purposes</td>
<td>independently or collaboratively create and modify digital solutions, creative outputs or data representation/transformation for particular audiences and purposes</td>
<td>design and modify simple digital solutions, or multimodal creative outputs or data transformations for particular audiences and purposes following recognised conventions</td>
</tr>
<tr>
<td><strong>Communicating with ICT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborate, share and exchange</strong></td>
<td>use appropriate ICT tools safely to share and exchange information with appropriate known audiences</td>
<td>select and use appropriate ICT tools safely to share and exchange information and to safely collaborate with others</td>
<td>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</td>
</tr>
</tbody>
</table>
### Critical and creative thinking learning continuum

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

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## Personal and social capability learning continuum

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

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](http://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

You will need the following materials to complete this module:

- placemat materials
- digital camera
- a digital laser temperature gun thermometer, or a cooking thermometer
- cardboard boxes in a variety of sizes and styles
- foil
- newspaper
- scissors
- tape
- glue
- stapler
- additional materials as requested by students

**Water desalination experiment:**

- Large container such as a two litre glass microwave dish
- Second smaller container shorter than the top of the first container when it sits inside
- 1 teaspoon of table salt
- 2 cups of warm water
- Small weight such as a pebble, glass marble or glass bead
- Plastic food wrap
- A small graduated cup used for measuring liquid medicines in millilitres.

**Solar panel experiment:**

The minimum materials are to include:
Solar cooker testing:

- Two solar cookers
- Food to be heated
- A digital laser gun thermometer

Small solar panels

Small STEM project solar panel kits required for Activity 2 may be purchased from STELR online or hobby engineering stores (such as Jaycar Electronics, or Scientrific.com.au). Alternatively, high schools with solar panel kits may be willing to lend them for this experiment.

- Multimeter or separate ammeter and voltmeter.
- Small testing light bulb suitable for classroom electrical experiments such as a 1.5 volt mini lamp.
- Connecting leads with ‘piggy-back’ banana plugs or alligator clips.
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 more 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

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 a number of 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](http://www.tinkercad.com)
- Blog: [blog.tinkercad.com](http://blog.tinkercad.com)
- Tutorials: [www.tinkercad.com/learn](http://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
- Blog: [blog.sketchup.com](http://blog.sketchup.com)
- Tutorials: [www.youtube.com/user/SketchUpVideo](http://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

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

These modules encourage students to self-reflect and record the stages of their learning in a journal. This journal 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 journalling.

- Reflective journal (University of Technology Sydney)

- Reflective thinking (Association of Independent Schools of South Australia, 2013)

- 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 DoE portal for teachers
  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.

<table>
<thead>
<tr>
<th>Your name and group member’s names or photographs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>An explanation of the problem you are solving</td>
<td></td>
</tr>
<tr>
<td>Your notes from Activity 1</td>
<td></td>
</tr>
<tr>
<td>Your notes from Activity 2</td>
<td></td>
</tr>
<tr>
<td>Your notes from Activity 3</td>
<td></td>
</tr>
<tr>
<td>Your notes from Activity 4</td>
<td></td>
</tr>
<tr>
<td>Student activity sheet 2.2: Water desalination experiment</td>
<td></td>
</tr>
<tr>
<td>Student activity sheet 2.4: Solar panel experiment</td>
<td></td>
</tr>
<tr>
<td>Student activity sheet 2.5: Solar cooker testing</td>
<td></td>
</tr>
<tr>
<td>Student activity sheet 4.1: Prototype troubleshooting</td>
<td></td>
</tr>
<tr>
<td>Student activity sheet 4.2: Design review</td>
<td></td>
</tr>
<tr>
<td>Student activity sheet 1.0: Journal checklist</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 7: Teacher resource sheet 1.1: Cooperative learning – Roles

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, Time-keeper.
- 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.
Appendix 8: Teacher resource sheet 1.2: Cooperative learning – Jigsaw

This resource sheet provides a brief outline of a collaborative learning strategy known as ‘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, the 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>
<thead>
<tr>
<th>Step 1</th>
<th>Cooperative groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(of four students)</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Expert groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(size equal to the number of groups)</td>
</tr>
<tr>
<td></td>
<td>1 1 2 2</td>
</tr>
<tr>
<td></td>
<td>3 3 4 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
<th>Cooperative groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(of four students)</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>
Appendix 9: Teacher resource sheet 1.3: Cooperative learning – Placemat

This resource sheet provides a brief outline of a cooperative learning strategy known as ‘placemat’.

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 placemat strategy involves students working collaboratively to record prior knowledge about a common topic and brainstorm ideas. It also allows teachers to readily see the contribution of each student. The diagram below shows a typical placemat template.
Appendix 10: Teacher resource sheet 1.4: Cooperative learning – Think, Pair, Share

This resource sheet provides a brief outline of a cooperative learning strategy known as ‘think – pair – share’.

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.

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, the students share their answer, their partners 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.

Think – pair – share increases student participation and provides an environment for higher levels of thinking and questioning.
Appendix 11: Teacher resource sheet 2.1: Solar panel experiment

Links to the Western Australian Curriculum

Science | Science understandings | Physical sciences | Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Introduction:
Photovoltaic cells (solar panels) transform light energy into electrical energy. This experiment investigates the effect of light intensity on the electrical output of photovoltaic cells.

Design:
This experiment relies on measuring the current and voltage of an electric circuit powered by a solar cell and manipulating the intensity of sunlight directed at the panel.

Two 70mm by 40mm panels connected in series will generate approximately 1 volt and 90 milliamps (measurable with a multimeter or appropriate bench meters), this will produce a dim glow from a 1.5 volt mini lamp. Larger solar panels or more joined together will be required to power larger lamps.

Safety notes:
- When performing experiments in the sun, be sure to wear sun safe clothing, a hat and sunscreen.
- The light bulb may become hot.

Materials:
- Small solar panels (refer to comments above).
- Multimeter or a separate ammeter and voltmeter to measure electrical output.
- Small testing light bulb suitable for classroom electrical experiments such as a 1.5 volt mini lamp.
- Connecting leads with ‘piggy-back’ banana plugs or alligator clips.
**Procedure:**

**Solar cell circuit:**

1. Set up the solar cell circuit as shown above. Voltage is measured in parallel across the circuit and current is measured in series with the lightbulb. Bench top meters or a multimeter may be used.

2. Place the solar panel circuit in the sunlight and record the voltage and current. If readings fluctuate, take an average or approximate.

3. Light meters could also be used to measure the intensity of light on the panels.
Appendix 12: Student activity sheet 2.2: Solar panel experiment

Questioning and predicting:
What are you going to investigate (aim or purpose of the experiment)?

Design your test:
What do you predict will happen?

________________________________________________________________________

In the space below provide a labelled diagram of your circuit:

________________________________________________________________________

For each location, calculate the power output of the solar panels. Since current was measured in milliamps, the units for power (P) will be recorded as milliwatts (mW) and is calculated by:

\[ P = V \times I \]

<table>
<thead>
<tr>
<th>Location</th>
<th>Power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Investigate:

Conduct a range of tests to measure the effect of varying the light intensity on the electricity. This could include varying the angle at which the solar cell is facing into the sunlight, and/or take measurements in varying amounts of shade. Voltage should be measured in volts (V) and current (I) should be measured in milliamps (mA)
Was your prediction correct?

Convert the maximum power achieved by your model solar panel to the units of watts (W) where milliwatts to watts requires dividing by 1000.

Maximum power of model solar panel achieved: _____ mW
Converted to watts (milliwatts divided by 1000): _____ W

Consider the power requirements to operate common household appliances. Some examples are shown below:

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Power Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laptop computer</td>
<td>50 W</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1200 W</td>
</tr>
<tr>
<td>LED lightbulb</td>
<td>7 W</td>
</tr>
<tr>
<td>Alarm clock radio</td>
<td>1 W</td>
</tr>
<tr>
<td>Electric oven</td>
<td>2200 W</td>
</tr>
<tr>
<td>Charge a mobile phone</td>
<td>2 W</td>
</tr>
</tbody>
</table>

Which appliance is most necessary in a developing country?
Using the lightbulb as an example, calculate how many model solar panels are required to generate the power output needed:

Number of panels = (power required)/(power output of one model panel)

Number of panels = _______

Were there any ways you could have improved your investigation?

(Think about your procedure, how you recorded your measurements, what you might have done differently).

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Appendix 13: Teacher resource sheet 2.3: Water desalination experiment

Introduction:
The ability to source of drinkable water is essential of off-the-grid-living. Sea water contains too much salt to safely drink. The process of removing salt from water is called desalination; by removing the salt from the water it becomes safer to drink.

Note: This activity could take considerable time, and is likely to only be effective in relatively warm weather.

Purpose:
The purpose of this experiment is to test the efficiency of a simple solar still.

Design:
The design of this solar still relies on the evaporation and condensation of water which is collected in an internal reservoir.

Materials:
- Large container such as a two litre microwave dish
- 1 teaspoon of table salt
- 2 cups of warm water
- Second smaller container shorter than the top of the first container when it sits inside
- Small weight such as a pebble, glass marble or glass bead
- Plastic food wrap
- Spoon
- A small measuring cup used for measuring liquid medicines in millilitres.
**Procedure:**

**Solar desalination set-up**

1. Place 500 mL (two cups) of warm, contaminated (muddy) water into the large container.
2. Place the empty smaller short container into the centre of the large container.
3. Place plastic wrap over the larger container letting it sink a little in the centre and ensure a tight seal around the edge of the large container.
4. To ensure that the condensed water can be captured in the smaller container, place a small weight onto the plastic directly above the smaller container.
5. Place your solar still in direct sunlight outside the classroom and record the time.
6. When a sufficient quantity of water for testing has collected in the small container, remove from the direct sunlight and record the time.
7. Measure the volume of the water that collected in the small container using the graduated cup.
8. Observe the water collected in the smaller dish.
Discussion
Using coloured arrows, demonstrate the desalination process and write the words ‘evaporation’ and ‘condensation’ on the arrows.
Appendix 14: Student activity sheet 2.4: Water desalination experiment

Complete the table with observations from the experiment

<table>
<thead>
<tr>
<th>Water type</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled</td>
<td></td>
</tr>
</tbody>
</table>

How long did it take to collect the water in minutes?  ________ min

How much water was collected in millilitres?  ________ mL

Calculate the rate of desalination with units of mL/min:

Rate of desalination
= (Volume of water collected)/(time experiment was in the sun)
= ________ mL/min

Convert the rate of desalination from units of mL/min to units of L/h
Convert millilitres to litres: ________ mL/_____ mL in 1 Litre = ________ L
Convert minutes to hours: ________ min/____ minutes in 1 hour = ________ h

Rate of desalination
= (volume of water collected [L])/(time experiment was in the sun [hours])
= ____________ L/h

How much desalinated water could this still produce per day? Consider the heat of the Sun through the day and make an estimate of how many hours per day the Sun would be shining intensely on the solar still.

Estimated number of hours per day the Sun shines intensely on experiment: ________ h
Hourly rate of desalination (previously calculated): ________ L/h
Daily rate of desalination (L/h) x hours sun shining intensely per day: ________ L/day
Consider the amount of desalinated water produced and how long that took. Do you think the solar still could produce enough drinking water for one person for one day?

How might the design of the solar still be changed to produce desalinated water at a faster rate?

If you were in the bush on a hot day and your car broke down, can you think of other ways you could collect water that is safe to drink?
Appendix 15: Student activity sheet 2.5: Solar cooker testing

Introduction:
Solar cookers utilise energy from the Sun to heat and cook food. In this activity you will design and build a solar cooker and test its performance. The maximum temperature reached and the time it takes to increase in temperature (rate) are just possible criteria for measuring the performance of the solar cooker.

Design:
A minimum of two solar cookers are to be compared, your group’s solar cooker and the data from a second group’s solar cooker.

Safety notes:
- The solar cookers are to be place in the sunlight. Wear sun safe clothing including a hat and sunscreen if collecting data in the Sun.
- The cooker and food in it get very hot and care must be taken to avoid burns.
- Ensure the cooker is in an open area away from dry grass or other easily flammable materials.

Materials:
- Two solar cookers
- Piece of food to be heated
- A laser thermometer or a cooking thermometer that could be placed inside the solar cooker

Questioning and predicting:
What are you going to investigate? (Aim or purpose of the experiment).

What do you predict will happen? (2)

Procedure:
Solar cooker set-up
1. Place the two solar cookers being compared in the sunlight close together so they experience similar heat and light conditions.

2. Place the food in the solar cookers.

3. Take note of the time the solar cooker is ready to start working (cooker in the sunlight and food in place).

4. Take a measurement of the temperature of the food at the start of the experiment with the thermometer.

5. Take progressive measurements of the temperature of the food every two minutes, record the temperature on the table below.

6. Observe and record any changes to the food or other points of interest.

Results:

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Cooker 1 (Your cooker)</th>
<th>Cooker 2 (Cooker of another group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
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<td>30</td>
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</tbody>
</table>

Additional rows to be added if required.

In the spaces below draw labelled diagrams of the cookers that were compared (please make sure diagrams are drawn in pencil and materials labelled).

Note the type of cookers in the picture.
| **Cooker 1**  
(Your cooker) | **Cooker 2**  
(Cooker of another group) |
Note any observations throughout the cooking time

<table>
<thead>
<tr>
<th>Observations</th>
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<tbody>
<tr>
<td>Cooker 1</td>
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</table>

**Processing and analysing data and information:**

Was your prediction correct? Explain.

________________________________________________________________________

________________________________________________________________________

In what units did you measure temperature? ______

What was the maximum temperature reached for each cooker (show units)?

- Cooker 1 maximum temperature: ______
- Cooker 2 maximum temperature: ______

How long did it take to reach the maximum temperature?

- Cooker 1 time to maximum temperature: ______
- Cooker 2 time to maximum temperature: ______
How many degrees did the temperature increase in the first ten minutes?

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<thead>
<tr>
<th></th>
<th>Cooker 1</th>
<th>Cooker 2</th>
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</thead>
<tbody>
<tr>
<td>Temperature at start time</td>
<td></td>
<td></td>
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<tr>
<td>Temperature at 10 minutes</td>
<td></td>
<td></td>
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<tr>
<td>Degrees change from 0 to 10 min</td>
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</table>

What was the rate of increase of temperature in the first ten minutes in °C per second?

Number of seconds in ten minutes

= Number of seconds in 1 minute: _______ × 10 minutes

= _______ seconds

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<th></th>
<th>Cooker 1</th>
<th>Cooker 2</th>
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<tbody>
<tr>
<td>Degrees change from 0 to 10 min</td>
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</tr>
<tr>
<td>(Degrees change in 10 min) divided by (Number of seconds in 10 min)</td>
<td>°C per second</td>
<td>°C per second</td>
</tr>
</tbody>
</table>

Place brackets in the correct place in the formula below to show the correct order of operation for calculating °C per second:

°C per second = temp at 10 min – temp at start + sec in 1 min × 10 min
Draw the appropriate graph to represent the temperature measurements of your solar cooker.

How many degrees had the temperature increased by from 10 minutes up to the maximum temperature?

   Cooker 1: _______

   Cooker 2: _______

**Evaluating:**

Why do you think the cookers produced different results?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Were there any external factors to the design that may have impacted the solar cooker performance?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
What are some advantages and disadvantages to using solar cookers?

Advantages:

_________________________________________________________________________________________________________

Disadvantages:

_________________________________________________________________________________________________________

Do you think it would be appropriate to cook all types of food with a solar cooker? Explain:

_________________________________________________________________________________________________________

List any errors you may have made in your investigation? (Errors can be carrying out the experiment – measurements, observations, or they can be equipment errors).

_________________________________________________________________________________________________________

Were there any design changes your group made ‘on the run’ that may have helped or limited the performance of your solar cooker?

_________________________________________________________________________________________________________

Explain in detail two ways you could have improved your investigation? (Think about how you carried out the procedure, improvement of measurements or what you might have done differently.)

_________________________________________________________________________________________________________

_________________________________________________________________________________________________________
## Appendix 16 Student activity sheet 3.1: Prototype troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Reason for the problem</th>
<th>Possible changes to your design to solve the problem</th>
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</table>
Appendix 17: Student activity sheet 4.2: Design review

Things I would keep the same with reasons why

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Things I would change with reasons why

________________________________________________________________________
________________________________________________________________________
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________________________________________________________________________
________________________________________________________________________

Photograph or drawing