Department of Education

GOVERNMENT OF WESTERN AUSTRALIA

CURRICULUM RESOURCE MODULE

Water games

YEAR 7

THE STEM LEARNING PROJECT

scitech

MAWA

STAWA SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

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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.

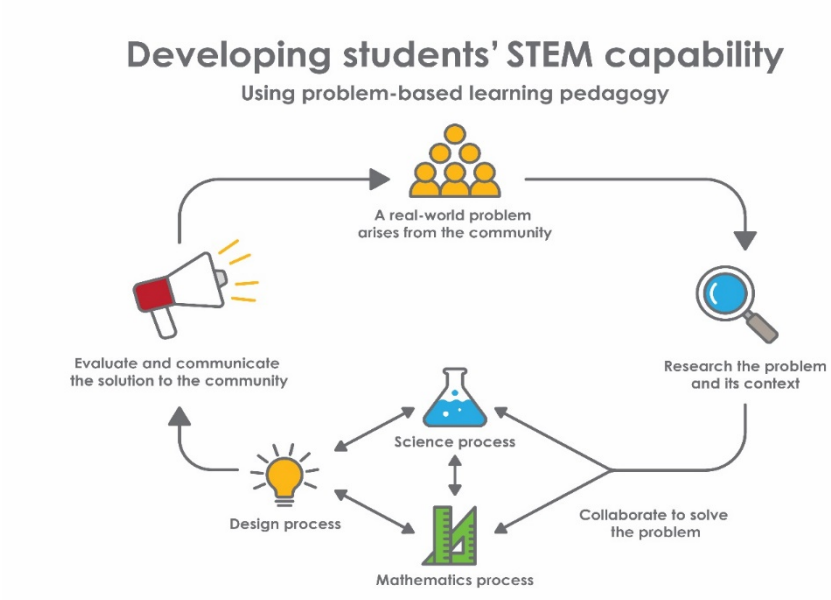
Why STEM?

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.



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Year 7 – The water games

Overview

The growing global population combined with dwindling supplies of clean water is challenging the future sustainability of water. Demand continues to outstrip supply which places many communities at risk.

In Western Australia, '*A long term, sustained focus on using less water is central to living with less rainfall and becoming climate resilient. Our goal is to reduce water use by 15% by 2030' (Water Corporation, 2017).*

GRID-Arendal, a centre collaborating with the United Nations Environment Programme (UNEP), suggests that with the predicted population growth mankind may be moving '*toward a world of thirst*' by 2050 if we keep consuming water at the same rate. *The water games* module engages students through the recognition that this issue affects their future. It provides students the opportunity to lead change now, so they can develop a sustainable future.

What is the context?

The world is changing and technology is leading to innovations in how we think, create and solve problems for future generations. Students will represent a team of scientists, mathematicians, engineers and researchers who have been contracted to produce an effective water saving strategy.

What is the problem?

Current water saving strategies and campaigns from Water Corporation are having an effect, but the risk of demand outstripping supply still remains. What gamification process can be designed that will change people's habits towards water saving and result in reducing demand?

How does this module support integration of the STEM disciplines?

Using science, technology and mathematics to address a real-world problem, students draw on prior knowledge and learn new principles to collaboratively produce a solution.

Science

Students develop an understanding of water being an important resource that cycles through the environment (ACSSU222). Students will understand that despite water being considered a renewable resource (ACSSU116), there are challenges in ensuring an adequate supply of drinking water. In order to reuse water, usable water needs to be separated from mixtures, including solutions, using a range of techniques (ACSSU113).

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Technologies

Students use the design process from the Technologies curriculum to investigate, define, design, produce, implement and evaluate a gamification solution to increase water savings. Student groups collaborate and manage the project with guidance from the teacher.

Students develop success criteria for their project and use this to interpret which project ideas have a better chance of success.

Students present their solution by communicating their design ideas, plans and processes to an audience using digital technologies and multimodal representations including an infographic (ACTDIP026).

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

Students use mathematics to achieve an understanding of their water footprint. They collect class data using a website, converting their footprint from US gallons to litres (ACMNA156, ACMNA173). Students calculate the mean, median, mode, range of the student data, and use this to generate insights for their project ideas (ACMSP171) and make displays (ACMSP172). Summing all the data, they visualise the large numbers by converting them to Olympic-sized swimming pool units by calculating the volumes of rectangular prisms (ACMMG160, ACMNA154, ACMNA156, ACMNA173). Students analyse data on Perth's water sources and calculate the percentage provided by each source (ACMSP169, ACMNA157, ACMNA158).

General capabilities

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

- Develop critical and creative thinking skills as they research the problem and its context (*Activity1*); 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 problem.
- Utilise personal and social capability as they collaborate in generating solutions; adopt group roles; and reflect on their group work capabilities.

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- Utilise a range of literacies and information and communication technology (ICT) capabilities as they collate records of work completed throughout the module in a journal; represent and communicate their solutions to an audience using digital technologies in *Activity 4*.
- Communicate and, using evidence, justify their group's design to a broader audience.

There are also significant opportunities for students to develop enterprise skills.

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.

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Activity sequence and purpose

Activity 1

RESEARCH

Students' interest in water saving is captured and they are challenged to devise effective water saving strategies.

H_2O – No!

Activity 2

INVESTIGATE

Students collect data on their personal water footprint and scale this to see how decisions made by individuals impact on the sustainability of water supply.

Students develop an understanding of the water cycle, water resources and water purifying techniques.

Your water footprint

Activity 3

IMAGINE & CREATE

Students design a gamification solution that motivates people to use a water saving strategy.

A solution that works

Activity 4

EVALUATE & COMMUNICATE

Students create a digital representation of their solution and present it to peers and invited guests. Opportunities are provided for self and peer evaluation of both the solutions and the group work collaborations.

Communicate and ruminate

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Background

Expected learning

Students will be able to:

1. Explain why conserving safe drinking water is both a local and global problem.
2. Identify potential techniques that could be used to more effectively engage the community with water saving strategies.
3. Use the water cycle to illustrate and explain how water is a renewable resource.
4. Explain the processes that enable water to be cycled through the environment and the sources from which we draw water for human consumption.
5. Construct an infographic to represent water source data and show changes in patterns of use.
6. Explain how filtration can be used to remove particulate matter from water and distillation can be used to recover water from a solution.
7. Collate, analyse and interpret data collected on water footprints and represent findings using appropriate measures of central tendency.
8. Analyse water source and usage data using fractions, decimals and percentages.
9. Analyse and interpret secondary sources of data regarding sources of water.
10. Calculate volumes of water contained in rectangular prisms.
11. Imagine, create, design and evaluate a gamification solution to the problem of motivating people to use a water saving strategy.
12. Develop success criteria that can be used to guide the design and evaluation of a gamification solution.
13. Contribute and collaborate effectively in program planning, implementation and management.
14. Create solutions involving game mechanics that motivate users.
15. Explain why there is a need to conserve water and give a rationale for their project.
16. Communicate their solution to an audience and justify their design choices.
17. Use defined success criteria to evaluate the effectiveness of their solution.
18. Reflect on the design process and determine what worked well and what could be improved.

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Enterprise skills	As students work in teams to develop solutions that will engage the community in water saving measures there are opportunities for the development of enterprise skills. 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*' report *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*
Vocabulary	The following vocabulary list contains some terms that need to be understood, either before the module commences or developed as they are used: aquifer, artesian, condensation, contaminated, evaporation, desalination, game mechanics, gamification, greywater, hypothesis, infiltration, potable, precipitation, protozoa, reverse osmosis, sustainability, transpiration, turbid, virtual water usage, wastewater, water footprint.
Timing	There is no prescribed duration for this module. The module is designed to be flexible enough for teachers to adapt. Activities do not equate to lessons; one activity may require more than one lesson to implement.
Consumable materials	A *Materials list* is provided for this module. The list outlines materials outside of normal classroom equipment that will be needed to complete the activities.
Safety notes	There are potential hazards inherent in these activities and with the equipment being used, and a plan to mitigate any risks will be required. Potential hazards specific to this module include but are not limited to: • Consumption of contaminated water

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Assessment

The STEM modules have been developed to provide learning experiences in which students solve authentic real-world problems using science, technology, engineering and mathematics capabilities. While working through the module, assessment opportunities will arise as outlined below.

- Students participate in gathering data, interpreting data, making calculations and constructing data representations and reports which provide opportunities for individual assessments.
- Some tasks are completed as collaborative activities and these can provide opportunities for formative assessment.

Appendix 1 indicates how the activities are linked to the Western Australian Curriculum.

Students will also have opportunities to further develop the general capabilities of Information and communication technology capability, Critical and creative thinking and Personal and social capability. Continuums for these are included in the *General capabilities continuums* but are not intended to be for assessment purposes.

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Activity 1: H_2O – No!

Activity focus

This activity is designed to capture students' interest in the global issue of water saving as an issue which requires a local response. Students develop understandings about water sources and the need to conserve water resources.

Background information

Water is our most important natural resource and is necessary to sustain life. Water makes up most of our body tissues and we need to drink water to replace that lost through excretion, sweating and breathing. It is a vital resource that cycles through the environment, evaporating from oceans, lakes and rivers. As water vapour rises through the atmosphere it cools, condenses and falls back to the earth as rain. Some rain percolates through the soil into the water table and the remaining rain water runs into dams or into rivers and back to the ocean. In Western Australia, our main sources of water are groundwater, water derived from the sea by desalination and water collected in dams. Rainfall has declined significantly in the south west of the state and so there has been reduced run-off into dams. Therefore, we have had to rely more heavily on groundwater and desalination. Reduced rainfall has resulted in reduced recharge of aquifers such as the Gnangara Mound so that it has become necessary to inject treated waste water into the aquifers to recharge them.

Providing adequate supplies of safe drinking water is a major challenge for developing countries and is *Goal 6* in *The Global Goals for Sustainable Development* and *Goal 7C* in the *United Nations Millennium Development Goals*. These goals set ambitious targets to reduce, reuse and recycle water. In Western Australia, Water Corporation promotes many water saving strategies which are outlined on its website at *www.watercorporation.com.au* .

In this module, students consider gamification techniques as one method to motivate the general population to make water saving a habit. Gamification is the application of game-design elements and game principles in non-game contexts to help people understand and engage with issues. For further information on game mechanics see *Teacher resource sheet 1.5: Game mechanics*.

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Instructional procedures	*Activity 1* sets the scene for the entire module. The basis of the challenge set before the students is that although people know that water needs to be saved, our community is still not reducing its water consumption to a level that is sustainable. To have a sustainable future, communities need to ensure they conserve water resources and encourage individual action for this global issue. Therefore, the idea presented to the students is that if we could make water saving fun, more people would participate. Students will work in groups of three or four and will look at gamification techniques as one method to motivate the general population into making water saving a habit. The idea is that gamification is included in the students' final solution. Reflection questions have been used throughout the module to capture not only students' thoughts on the topic, but also to have them think about how they are collaborating in their groups. By reflecting on their group's progress, students can evaluate and re-think how their group might work better in the next stage of the process.
Expected learning	Students will be able to: 1. Explain why conserving safe drinking water is both a local and global problem (Science). 2. Identify potential approaches that could be used to more effectively engage the community with water saving practices (Technologies).
Equipment required	**For the class:** Internet access (or can be done without) Butcher's paper and marker pens Poster putty to attach butcher's paper to walls
	For the students: Devices (computers, tablets)
Preparation	**Part 1:** • Print out posters for *The Global Goals for Sustainable Development – Goal 6* and *United Nations Millennium Development Goals – Goal 7C* (see *Digital resources*).

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Part 2:

- Make available a projection of Water Corporation's website or student access to devices for browsing.

Part 3:

- Prepare to show the National Geographic video *Why Care about Water?* (see *Digital resources.*)

Part 4:

- Prepare the timer so it is ready to start.
- Prepare an app, device or other means to capture the ideas brainstormed by the class.
- Print out placemat activity sheets (one per group).
- Provide butcher's paper to capture ideas.

Part 5:

- Make available, a website providing information about and demonstrations of showing gamification methods (eg *Gamified UK*).
- Produce a poster or printed list of the game mechanics (see *Digital resources*).

Part 6:

- Provide butcher's paper to capture ideas.

Activity parts

Part 1: Introduction to the module

Outline to students the structure of the learning experience:

- They will be working in groups of three or four.
- They will be given a challenge and required to create a solution.
- Their solution might just save the world!

Set the scene. Read out the following script to students (add or change as desired).

Weather records indicate that the south west of Western Australia is receiving far less rainfall than in previous years. This means that run-off into dams has declined. On top of this an increase in population and hence increased demand, met from other sources, has meant that dams now supply only 5% of drinking water for Perth when they once supplied 95%. We need to save drinkable water in order to have a sustainable future.

Many water saving strategies exist such as sprinkler days, shorter showers, fix the drip and not leaving the tap running. Yet we still continue to use more water than in previous years. So why aren't we saving more water?

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Challenge students to find an answer. In groups, students need to find a way to make water saving happen by devising a gamification method that motivates people to employ water saving strategies.

Share with students *Goal 6* in *The Global Goals for Sustainable Development* and *Goal 7C* of the *United Nations Millennium Development Goals.*

The Global Goals for Sustainable Development
www.globalgoals.org

United Nations Millennium Development Goals
www.un.org/millenniumgoals

Part 2: Water saving targets

Review the information on Water Corporation's website under the tab 'Save water' at
www.watercorporation.com.au

Talk through the targets. Focus on the targets that relate specifically to this topic.

- Do you think we will meet these targets? Why? Why not?
- What is stopping us from meeting these targets?

It is recommended that each group comes up with their own group name to initiate some team-building. Teams may also wish to create their own logo.

Students answer the following questions and record in their learning journal:

- What excites you about this challenge?
- What worries you about this challenge?
- What capabilities you can bring to the group? Why?
- What will be your biggest challenge working in a group?

Further information can be found in *Teacher resource sheets 1.1 – 1.4 on Cooperative learning*.

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Part 3: Why don't we save more water?

Students watch the National Geographic video *Why Care About Water?* Discuss the video with the class.

The video should provoke students to want to saving water.

Class debrief questions can include:

- How do you feel now after watching the video?
- What does the narrator mean by 'water is a global issue, but it is also a very local issue'?
- How might you motivate people to use water saving strategies on a global scale eg. An app that is used by people from all around the world.

Part 4: Brainstorm

Instruct students: *As a class, we will list some useful water saving strategies. We will add to the list throughout the module. Your group task is to design a motivation technique for one or more of these strategies that the public will use.*

The Placemat teaching strategy can be used to ensure each student is accountable for listing ideas. See *Teacher resource sheet 1.3: Cooperative learning – Placemat*.

Team roles could be allocated for this task. For example:

1. A writer – to write down all ideas generated by the team and to ensure no ideas are negated by other team members.
2. A time-keeper – to ensure the team meets the time deadline by reminding the team how much time they have left.
3. An encourager – when the team is running low on ideas, the encourager selects individuals to generate new ideas.
4. A director – ensures the team remains on task.

More information on group roles is provided in *Teacher resource sheet 1.1: Cooperative learning – Roles*.

Challenge students to list as many water saving strategies as they can in five minutes. A timer, such as *Bomb Timer* (see *Digital resources*), can be used to encourage students to participate in the task. These ideas could be existing water saving strategies or completely new ideas.

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When the five minutes is finished, gather all the ideas together on a whiteboard or in a digital app such as *Padlet* or *Popplet* displayed through a projector for the class.

Allow time for each group to decide which two strategies might be most effective and which two strategies might be least effective, and be able to explain why. Ask each group to elect a speaker to present their group's ideas to the class. Capture the ideas with a photo or save in the app for future use.

Group debrief questions can include:

- How well did you work together as a group today?
- In your group, what worked well?
- What could have been improved?
- How will you work differently next time?

These questions can be used after any group task to focus on effective collaboration, group work and leadership which helps develop skills required for jobs of the future.

Part 5: Motivating a strategy – Gamification

Introduce the students to the concepts of gamification and game mechanics.

The techniques of gamification can be used to motivate people to change their behaviour. In this problem, it is to encourage the use of a water saving strategy. This means using elements of game mechanics to leverage people's natural desires for competition, achievement, status, altruism, community collaboration and more. A motivating game could be developed into an app for phones or other devices.

Teacher resource sheet 1.5: Game mechanics provides advice and a link to more information on game mechanics. This needs to be reviewed with the class to develop an understanding of gamification. The list of game mechanics could be displayed in the classroom or provided to each student or group.

A class activity involving research and discussion to find current real-world examples of the various gamification techniques would also help develop students' understanding.

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Later, in *Activity 3,* students will use aspects of gamification to motivate people to use an existing or new water saving strategy.

Part 6: Capturing ideas

At this stage of the project, it is good for groups to start capturing their insights and any useful information they have discovered through their learning. This will help students to ideate solutions for their project.

Using butcher's paper, groups capture their ideas about new and existing water saving strategies they could promote, and about the gamification techniques they might use to promote water saving strategies. Information captured from the previous parts of this activity can be used to help prompt the students.

Ensure students are respectful of ideas generated by other students; no idea is a bad idea. Encourage students to write down ideas from all group members. Remind students that there are many possible solutions to the water saving problem.

At this stage, it is important students do not prematurely decide on a solution to the problem. The aim is for students to be able to capture a range of ideas and later choose the solution that is going to be the most effective.

Ideas could involve:

- Promoting inventions that reduce, reuse or recycle water.
- Motivating the use of an existing water-saving strategy that has been revamped.
- Developing an app or device that encourages water saving.
- Running a competition that encourages individuals to compete to save water.

The butcher's paper should be readily available so the group can add more ideas as they generate them.

Resource sheets

Teacher resource sheet 1.1: Cooperative learning – Roles

Teacher resource sheet 1.3: Cooperative learning – Placemat

Teacher resource sheet 1.5: Game mechanics

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Digital resources	*Virtual tours of Water Corporation treatment plants* (Water Corporation, 2017) www.watercorporation.com.au/home/education/school-talks-and-excursions/virtual-tours
	Poster: *The Global Goals for Sustainable Development* (The Global Goals for sustainable development, 2017) www.globalgoals.org
	Poster: *United Nations Millennium Development Goals* (United Nations, 2015) www.un.org/millenniumgoals
	Why Care About Water? (National Geographic, 2010) www.youtube.com/watch?v=Fvkzjt3b-dU&feature=youtu.be
	Bomb Timer (Online Stopwatch) An online stopwatch (mute tab to avoid loud blast) www.online-stopwatch.com/bomb-countdown/full-screen
	Padlet padlet.com
	Popplet popplet.com
	52 Gamification mechanics and elements (Gamified UK, 2017) www.gamified.uk/user-types/gamification-mechanics-elements

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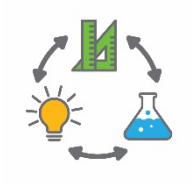
Activity 2: Your water footprint

Activity focus



In this activity students gather data about their own water footprint to better understand how much water they use. Analysis of the water cycle and water source data helps students understand how the demand for water is met. Filtration and distillation are investigated as ways of purifying contaminated water and methods of recycling waste water are also considered.

Background information

The topic of water has a strong link to the Humanities and Social Sciences curriculum. Teachers might like to investigate some cross-curricula activities with the Humanities and Social Sciences learning area to coincide with this project.

It is important to note that the Perth desalination plants are now producing roughly one-half of the city's fresh water requirement. However, this source of fresh water has a large capital expenditure and ongoing need for energy. Generating this energy from coal or gas means the plants have an environmental cost that needs to be considered in their overall sustainability equation.

There are opportunities for developing mathematical competencies related to recording data in spreadsheets, scaling-up quantities, conversion from imperial to metric units, calculating volumes of rectangular prisms and calculating percentages.

Students should be spending most of the time in their groups so they can discuss ideas with their team members and capture their insights. Cross-collaboration between groups can be facilitated to share ideas around the class.

Activity 2 is not yet the time for choosing a solution to the problem of reducing water consumption. However, teachers should encourage students to be capturing their insights throughout this activity to prepare them for *Activity 3* where they will eventually select, design and implement a gamification solution that motivates people to use a water saving strategy.

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Expected learning	Students will be able to: 1. Use the water cycle to illustrate and explain how water is a renewable resource (Science). 2. Explain the processes involved in the cycling of water through the environment and the sources from which we draw water for human consumption (Science). 3. Construct an infographic to represent data about water sources and to show changes in patterns of use (Science and Technologies). 4. Explain how filtration can be used to remove particulate matter from water and distillation can be used to recover water from a solution (Science). 5. Collate, analyse and interpret data collected on water footprints and represent findings using appropriate measures of central tendency (Mathematics). 6. Analyse water source and usage data using fractions, decimals and percentages (Mathematics). 7. Analyse and interpret secondary sources of data regarding sources of water (Mathematics). 8. Calculate volumes of water contained in rectangular prisms (Mathematics).
Equipment required	**For the class:** Access to a spreadsheet program such as *Microsoft Office 365 Excel* or *Google Sheets* Teacher device with access to a projector (or seek alternative options for these activities) See *Materials list* for the equipment and materials needed for each part of the activity
	For the students: Access to a collaborative spreadsheet program such as *Microsoft Office 365 Excel* or *Google Sheets* Access to a presentation tool such as *Microsoft Office 365, PowerPoint* or *Google Slides* (or a paper-based alternative) Butcher's paper and marker pens
Preparation	See *Resource sheets* and *Digital resources* for links to the documents and videos used in this activity. **Part 1:** • Print or provide digital access to *Student activity sheet 2.1: Unit conversions*.

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- Teachers unfamiliar with spreadsheets might like to access tutorials online. There are many available at this link: *www.thoughtco.com/free-spreadsheet-tutorials-3123959*
- Prepare the *Water Footprint – Class Template* spreadsheet as a template for the class to input their data.

Part 2:

- Make a copy of the completed spreadsheet.
- Print or provide digital access to *Student activity sheet 2.2: Olympic swimming pools*.
- Infographics apps such as *Canva* and *Adobe Spark* require students to have an account. These are free, but will need to be established by the teacher.

Part 3:

- Print or provide digital access to *Student activity sheet 2.4: The water cycle*
- Prepare to watch the chosen water cycle video.

Part 4:

- Print or provide digital access to *Student activity sheet 2.5: Perth's water sources*.

Part 5:

- Prepare to watch Water Corporation's video *Our water sources – WA's wastewater system*.

Part 6:

- Print or provide digital access to *Student activity sheet 2.6: Purifying contaminated water*.
- Source equipment and materials required for the filtering tests (see *Materials list*).
- Source equipment and materials required for the students to design and make their own water filters (if chosen).

Part 7:

- Source equipment and materials required for the option chosen.
- Prepare to watch *Water Corporation School Talks – Desalination.*

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Part 8:

- Prepare to watch the videos *Water conservation tips – How to conserve water at home* and *7 Weird Ways to Save Water.*
- Prepare to use an app to capture ideas from students.

Activity parts

Part 1: Calculating personal water footprint

Students calculate their personal water footprint using the online water footprint calculator:

Water Footprint Calculator (GRACE Communications Foundation, 2016) www.watercalculator.org

To complete their calculation, students need to select a USA state. Students should select California as it has a climate similar to Western Australia.

Once students have calculated their water footprint the following should be explored through class discussion:

- How their score compares to the US national average.
- Whether this average would be the mean, median or mode.
- Areas of high or low water usage in their results.
- The tips that are listed next to each topic.
- *Virtual Water Usage* (this might be a new concept that needs further explanation).
- The link in the bottom left hand corner to *Compare Yourself to Other Countries.*

This calculator gives an answer in US gallons, providing an opportunity to explore non-metric measurements and conversion to the students. This can be consolidated with *Student activity sheet 2.1: Unit conversions*. Students are not likely to be familiar with the difference between US gallons and litres. They should participate in a range of activities that provide opportunities for them to handle and compare the volumes and capacities of both units.

The Water footprint - Class templates (see *Digital resources*) are provided as a shared worksheet for entering data in US gallons. It will automatically convert these values to litres per day and per year. The templates are embedded in Appendix 20, but a full version is available in the STEM Learning Project Connect community.

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Students add their values into this shared class spreadsheet and all work in the same document initially to collect the class data.

The following prompt questions can be explored with the students:

- What did you learn about the water usage of your class?
- Where are the biggest areas for improvement as a class?
- Thinking about your project, in what area could your solution have the biggest effect? For example, agriculture.
- Has this prompted your thinking about ideas for your solution to the problem of motivating people to use a water saving strategy? Add any new ideas to your list.

Part 2: Create a visual representation of class water footprint

Students interpret the water footprint of their class by converting the usage values to Olympic size swimming pool units.

Students calculate the volume of an Olympic swimming pool using the dimensions: 50 m × 25 m × 2.5 m; and that one cubic metre is equivalent to one thousand litres (1 m^3 = 1000 L = 1 kL). Using this information, students calculate how many Olympic swimming pools the class water footprint would fill.

This work can be scaffolded using *Student activity sheet 2.2: Olympic swimming pools*.

This data can be displayed in an infographic using an app such as *Canva* or *Adobe Spark* (see *Teacher resource sheet 2.3: Infographics*).

Students print their infographics and include them in their journal. Students critique and provide feedback on each other's work.

Prompt questions can include:

- Looking at the infographic, what does this tell you about the class' water usage?
- Where could the class make the greatest water savings?
- What might this information look like for your school? For your community? State? Country? The world?

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- What are the per capita water usage figures for some other countries?
- How does this revelation make you feel?
- Has this prompted any new ideas for your solution? Add them to your list.

Students to choose the best infographic from the class and display it in the classroom.

Part 3: The water cycle

Now that students have gathered data about the ways in which they use water and the amounts used, it is timely to consider the water cycle.

Students unfamiliar with the water cycle should participate in a range of activities that enable them to investigate evaporation, condensation, precipitation and saturation. Activities such as the 'water cycle in a jar' will also help to develop their understanding.

Review the water cycle using one of the following videos:

The water cycle - Water Corporation
www.watercorporation.com.au/extras/WCWC/multiscreen.html

The Water Cycle – National Science Foundation
www.youtube.com/watch?v=al-do-HGuIk

Water Cycle Song – Have Fun Teaching
www.youtube.com/watch?v=TWb4KlM2vts

Learn about The Water Cycle – Turtlediary
www.youtube.com/watch?v=6-rVAeGrMsg

Students complete *Student activity sheet 2.4: The water cycle* to review the processes by which water cycles through the environment.

Part 4: Water sources

Perth's demand for water has increased with its rise in population. At the same time, the impact of climate change on rainfall in the south west of Western Australia has reduced the amount of water flowing into dams and the amount of water percolating through the soil into underground aquifers. Desalination of sea water is required to compensate for the reduced availability of water from dams and ground water.

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Students complete *Student activity sheet 2.5: Perth's water sources* to develop their understanding of the varying sources of our water supply and to practise calculating percentage change.

Part 5: How do we recycle wastewater?

Recycling of wastewater is another strategy that has been adopted to provide additional water supplies. Students watch the video *Our water sources – WA's wastewater system* from Water Corporation. www.watercorporation.com.au/water-supply/our-water-sources/recycled-water

Additional learning opportunity:

Water Corporation's website includes the following statements:

- We are committed to recycling 30% of wastewater by 2030.
- Over the last 10 years, we have increased the total volume of recycled water by almost 70% across WA.

Prompt the class with:

- What do these statistics mean?
- How could we use them?
- What information would we need to know first?

Have students find answers to the following questions:

- How many litres of wastewater will WA be recycling in 2030?
- How many litres of wastewater were we recycling 10 years ago?

Run this as an individual activity but encourage students to work through the process collaboratively.

Getting the correct answer is not as important as the mathematical process and thinking about how to find the answers to the questions. Give clues, such as directing the focus to the correct values to be used in the calculation, to scaffold the process as required, but not too soon. The problem should be 'uncomfortably challenging'.

Part 6: Purifying contaminated water by filtration

Many natural sources of water are contaminated by particulates and dissolved solutes. Particulates can be removed by filtration.

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Teachers read *Teacher resource sheet 2.6: Purifying contaminated water* describing the experiments students will complete. Then allow students to complete *Student activity sheet 2.6: Purifying contaminated water* which gives them an opportunity to test different filtering media and to investigate the impact of pore size on the effectiveness of a filter.

Alternatively, challenge students to design and make their own water filters. See *Materials list* for details on this and materials needed.

Students include a report of this work in their journals.

Part 7: Purifying contaminated water by distillation

Dissolved contaminants can be removed from water by distillation. Simple solar stills have been designed for use in developing countries and for emergencies when people are stranded in the bush. Fundamental to the operation of a still are the processes of evaporation and condensation.

Choose one or more of the following to complete with the students:

- Option 1: Demonstrate the Liebig condenser. See *Teacher resource sheet 2.7: Recovering pure water from a mixture*.
- Option 2: Challenge students to build a solar still. For example, see the *Science Buddies – Solar-Powered Water Desalination experiment* (see *Digital resources*).
- Option 3: Introduce this experiment as a challenge where students research, design and possibly build a home water still. Students could look at the 'Make It Your Own' tab on *Science Buddies* website.
- Option 4: Watch the Water corporation video on Desalination (see *Digital resources*).

Students include a report in their journals.

Part 8: Water saving ideas

As a class watch the video *Water conservation tips – How to conserve water at home* and discuss the water saving strategies shown. Add these to the brainstorm from *Activity 1*.
www.youtube.com/watch?v=4MDLpVHY8LE

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Water saving does not need to be boring. As a class, watch the video *7 Weird Ways to Save Water*.
www.youtube.com/watch?v=KX4RulbNdVw

Use this to inspire students to start thinking about ideas for their solution.

Use the following questions to prompt discussion on the likely popularity of these different water saving strategies:

- Which idea do you think has the potential to save the most water? Why?
- Which idea do you think would be the most appealing to people? Why?
- Which idea do you think would be the least appealing to people? Why?
- How could you change one unappealing idea to make it fun/engaging/exciting? For example, each time you washed your clothes in the shower, you pressed a button that adds up the water you have saved. Maybe this data could be saved to compete against your friends or people from around the world.

Write and capture the ideas on the whiteboard or on a digital app for current and future use.

Resource sheets

Student activity sheet 2.1: Unit conversions

Student activity sheet 2.2: Olympic swimming pools

Teacher resource sheet 2.3: Infographics

Student activity sheet 2.4: The water cycle

Student activity sheet 2.5: Perth's water sources

Teacher resource sheet 2.6: Purifying contaminated water

Student activity sheet 2.6: Purifying contaminated water

Teacher resource sheet 2.7: Recovering pure water from a mixture

Teacher resource sheet 2.8: Investigation extension

Teacher resource sheet 2.9: Water footprint – Class Templates

Digital resources

Water Footprint Calculator (GRACE Communications Foundation, 2016)
www.watercalculator.org

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Free Spreadsheet Tutorials (Ted French, 2016) www.thoughtco.com/free-spreadsheet-tutorials-3123959
Water Footprint – Class Template in the *STEM Learning Project Connect community*
Water Footprint – Class Template on Google Docs https://docs.google.com/spreadsheets/d/1s5F1Cc35dJmKF69Q4mLBTiM-eE4AdCDllumlczehJBc/edit#gid=0
*Wastewater (*Water Corporation, 2017) www.watercorporation.com.au/home/education/incursions-and-excursions/our-incursions/wastewater
What are biosolids? (Water Corporation, 2017) www.watercorporation.com.au/home/education/teaching-resources/find-a-lesson-plan/lesson-plan/what-are-biosolids
The water cycle – Do you know where our water comes from? (Water Corporation, 2017) www.watercorporation.com.au/extras/WCWC/multiscreen.html
The Water Cycle (National Science Foundation, 2013) www.youtube.com/watch?v=al-do-HGuIk
Water Cycle Song (Have Fun Teaching, 2015) A nerdy but catchy song www.youtube.com/watch?v=TWb4KlM2vts
The Water Cycle Lesson - Learn about The Water Cycle *(Turtlediary, 2012)* www.youtube.com/watch?v=6-rVAeGrMsg
Bomb Timer (Online Stopwatch) An online stopwatch (mute tab to avoid loud blast) www.online-stopwatch.com/bomb-countdown/full-screen
Our water sources – WA's wastewater system (Water Corporation, 2017) www.watercorporation.com.au/water-supply/our-water-sources/recycled-water
Designing, making and testing a water filter (Australian Science Innovations, 2013) scienceweb.asta.edu.au/verve/_resources/asta_5-1-3_ew_mixing_yr7_v1-3.doc

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	Desalination (Water Corporation, 2017) *www.watercorporation.com.au/home/education/school-talks-and-excursions/school-talks/desalination*
	Solar Powered Water Desalination (Science Buddies, 2017) *www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p022.shtml#summary*
	Water conservation tips – How to conserve water at home (Howdini, 2009) *www.youtube.com/watch?v=4MDLpVHY8LE*
	7 Weird Ways to Save Water (Youth Radio, 2014) *www.youtube.com/watch?v=KX4RulbNdVw*

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Activity 3: A solution that works

Activity focus 	The focus of this activity is to draw on what students have learnt about water use, water saving strategies and gamification to produce a workable solution that can be used to motivate people to implement a water saving strategy.
Background information	This activity focuses heavily on the design process as described in the Western Australian Curriculum: Technologies curriculum. It is important to understand that the process is more significant than the final product and the reflection process plays a key role in the development of ideas into a solution. See the *Design process guide* for further information. Students work in their groups from here on. Encourage the sharing of knowledge and ideas between groups; however, each group should be making their own unique solution. It does not matter if groups choose the same type of solution because the way they deliver it can be different. Each group may progress through these steps at different paces. They may have to 'go back to the drawing board' on a few occasions to improve their design. The teacher should decide how this is facilitated. The teacher may go through the process with the class once, and then students can go back to each stage of their own accord. Or, the material can be made available to them in an online classroom management app or website and have students access it at their own pace. This can be achieved through *Connect Content*. Students may choose a project management methodology or the teacher may choose one for the class (eg Waterfall model and Agile methodology in *Digital resources*). It is worthwhile making students aware of the different methodologies available so they can approach the task in an appropriate manner. Ideally students should make quick 'prototype' solutions that can be re-thought through each iteration, so the Agile methodology approach may be most suitable for this project. Reflection is key to the design process. Ensure students are using their journal to reflect on the process.

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Students may find *Student activity sheet 3.1: Prototype troubleshooting* a useful resource to direct their reflection.

Encourage students to reflect on at least one part of their journey towards the final solution.

For example, students could choose to reflect on a different part of the journey each day, such as:

- Individual effort – How do you think you contributed to the group today?
- Feelings towards the project – Do you feel you have the basis of a solution?
- Group participation and collaboration – List one good thing about the group's participation and collaboration, and one thing that could be improved.
- Challenges met – What issues caused problems or roadblocks for you?
- Project solution – Where are you at in terms of a solution?

Expected learning

Students will be able to:

1. Make design decisions about a gamification solution considering a range of success criteria (Technologies).
2. Imagine, create, design and evaluate a gamification solution to the problem of motivating people to use a water saving strategy (Technologies).
3. Identify success criteria that can be used to guide the design and evaluation of a solution (Technologies).
4. Contribute and collaborate effectively in the planning, implementation and management of a project (Technologies).
5. Create solutions involving game mechanics that motivate users through their application (Technologies).

Equipment required

For the class:

Projection device with internet access

For the students:

One-to-one or one per group devices with internet access

Preparation

Part 1:

- Print copies of the brainstorm ideas initiated in *Activity 1, Part 4*.

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Part 2:

- Print the list of water saving strategies.
- Print the list of game mechanics.
- Devise a method of randomly matching items from the two lists dependent on the option chosen.

Part 3:

- Provide access to a collaborative spreadsheet app.

Part 4:

- Provide materials to plan and design their solutions.
- Research on the internet a range of design brief templates for ideas students could include in their design.

Part 5:

- Plan for a break in the classroom schedule at this time to allow for the implementation and evaluation to occur. Perhaps two weeks on this part may be appropriate.

Part 6:

- Ensure students can access the rating system they created in *Part 3*.

Activity parts

Part 1: Review the current ideas on solutions

In *Activity 1* students began to formulate solutions to the problem. These ideas should have been added to or developed as the groups progressed through *Activity 2*.

At this point, teachers need to review the ideas generated and encourage students to consider the range of water saving strategies and problems investigated.

Part 2: Selecting the strategy and game mechanic

Each group narrows down the strategy and game mechanic they will use to motivate water saving using:

- The list of water saving strategies that was first generated in *Activity 1, Part 4*.
- The list of gamification ideas from the Gamified UK website *www.gamified.uk/user-types/gamification-mechanics-elements/*

See *Teacher resource sheet 1.5: Game mechanics* for further information.

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Once groups are assigned their strategy and game mechanic they can develop their solution based around them.

For example, using the strategy 'half-flush on the toilet' with the game mechanic 'points' might generate a solution of positive points for a half-flush, negative points for a full-flush, and bonus points for *'if it's yellow let it mellow'*. Any solution ideas should be captured on the group's butcher's paper. Students should think of a number of solution ideas in the given timeframe before selecting a final choice to develop.

A further period of brainstorming should take place so groups can consider many solutions based around their strategy and game mechanic. The Placemat strategy (see *Teacher resource 1.3: Cooperative learning – Placemat*) would be a great way to encourage accountability. Using another sheet of butcher's paper, groups should brainstorm possible ideas.

At this stage, students should not go into detail about the possible solutions and instead focus on getting down as many different ideas as possible.

To get the 'juices flowing', the teacher may want to walk students through all the activities that have been completed so far and ask pondering questions such as 'How might you use this in your solution? What could you take away from this idea? Solutions must reduce, reuse, recycle or in some other way help conserve water.

Once groups have completed their brainstorming they should look at the ideas of other groups and ask:

- What are we missing?
- What could we take from what other groups have done?
- Where are the missed opportunities?
- Can we combine two ideas?

Part 3: Compare solutions and choose development idea

In this part each group may start with a number of possible solutions. They need to determine what will make a solution successful, and hence which solution is their best.

As a class discuss which criteria might determine a successful solution. Capture these in a tool like *Padlet* or *Popplet*. These might include, but will not be limited to:

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- engagement/fun level
- how much water could be saved
- speed to market
- ease to develop.

Students choose which criteria they will use to rate their solutions, develop a rating system to compare and contrast the solutions, and then choose which one they will develop.

Students prepare their rating system in a collaborative spreadsheet app such as *Google docs* or *Office 365*. Each criterion chosen is placed in a row and each solution in a column.

The 'possible score' column will determine how much weighting each criterion will be allocated. In the example below, water saving is worth twice as much as engagement level and speed to market.

Students need to choose how much weight they apply to each criterion depending on what they think will make a successful solution.

Teachers may need to question students' assumptions and guide them. Groups then allocate points out of a possible score for each criterion of each project idea.

Criteria	Possible score	Solution 1	Solution 2	Solution 3
Engagement level	5	3	4	3
Water saving	10	8	9	6
Speed to market	5	2	3	5
Total	20	13	16	14
Percentage total	100	65	80	70

Students use the SUM function to calculate the total score for each solution, and a spreadsheet formula to calculate the percentage as a total of the overall score. This might be an opportunity to teach students about relative and absolute referencing when autofilling.

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More information on spreadsheet techniques is available at: *www.gcflearnfree.org/excel2013/relative-and-absolute-cell-references/1/*

The solution with the highest score should be chosen as the 'best' idea for the group. The focus for the students is to go through the process of thinking about what will make the project successful. If, after applying their criteria, they feel a need to change the weightings, this can be done.

Part 4: Plan and design your solution

Groups need to create a detailed design of their solution. Ask the question 'What questions must we ask (and later answer) to determine that our solution has been well designed?' Use *Padlet* or *Popplet* to capture these ideas which will likely match those in 52 Gamification mechanics and elements (see *Digital resources*).

Some questions they could ask include:

- What will our solution do?
- What gamification concepts have we employed?
- What will our design look like?
- What materials or equipment might we require?
- How will we explain our solution to other people?
- What will a successful solution look like?
- Is this the best plan for our solution? How could we make it better?
- How can we calculate how much water will be saved/recycled/reused?
- How will we determine the cost?

Groups need to document their solution and record it in their journal. Notes should include materials required, methods used, design elements and principles, how the user will interact with the solution and more.

Ensure students build success criteria into their designs. How will they know if they are successful at the end? Success criteria should be easy to quantify and should only have a 'success' or 'not a success' rating.

Are the success criteria ANDed together (all have to happen) or ORed together (only one has to happen) for the project to be a success? Or is 2 out of 3 a success? These success criteria are required later in the module.

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Part 5: Implement the solutions

Allocate time for students to implement and evaluate their solutions and reflect and refine them. A small trial initially may be useful. At this point it may be worthwhile to pause the module while the solutions are implemented. Students may need a few weeks to measure success, make adjustments and re-implement.

Implementation could be with the class, the year group, the school community or local community.

Part 6: How could your solution have more impact?

Evaluation, reflection and refinement are important parts of the design process. Students go back to their statements about how their solution will have the most impact.

The following questions are a guide to what students can consider at this stage of reflection.

- How could the product be redesigned/improved to have further impact (be more engaging, conserve more water, be more aesthetically pleasing etc)?
- Is the design working?
- Do we need to discard this design altogether and start from scratch?
- Which ideas could we use in a new design?

Students choose which improvements they will implement and move back to the design phase (as in *Part 4*).

Resource sheets

Design process guide

Teacher resource sheet 1.3: Cooperative learning – Placemat

Digital resources

Waterfall Method (Wikipedia, 2017)
en.wikipedia.org/wiki/Waterfall_model

Agile software development (Wikipedia, 2017)
en.wikipedia.org/wiki/Agile_software_development

Understanding agile project management methods using Scrum (H. Frank Cervone, 2010)

pdfs.semanticscholar.org/a639/ae4b486e8686a27325dcbfd470b350a13cc0.pdf

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	A Beginners Guide To Understanding The Agile Method linchpinseo.com/the-agile-method
	52 Gamification mechanics and elements (Gamified UK, 2017) www.gamified.uk/user-types/gamification-mechanics-elements
	List of game mechanics www.gamified.uk/user-types/gamification-mechanics-elements
	List Randomizer (Random.org, 2017) See the link for the iOS and Android apps www.random.org/lists
	Excel 2013: Relative and Absolute Cell References (GCF LearnFree.org, 2017) For information on spreadsheet techniques www.gcflearnfree.org/excel2013/relative-and-absolute-cell-references/1/

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Activity 4: Communicate and ruminate

Activity focus 	Two alternative activities are provided for *Activity 4*. Both are based around the *Evaluate and communicate* stage of the problem-solving process. Choice should be based on the desired learning, available time and expertise.
Background information	The presentation process is twofold. It is a culmination of all the hard work that has gone into the project and it is also used as the driver for students to motivate them throughout the project. The more stakeholders invited to the final presentations, the more buy-in there will be from the students throughout the process. The accountability that students have when they know they must stand next to their solution for all to see is the driving force to get the best out of them during this project. The reflection process is as important as the design process. By looking back at the project, students have another opportunity to learn; looking back to look forward. By evaluating what worked well and what could be improved, students can consider how they might choose to approach this type of task in the future and improve on their solution. This is why the process is more important than the final product.
Instructional procedures	Student presentations should be limited to eight to ten minutes. Students can choose the information to be included in their slides, however, they should try and incorporate their various redesigns as well as demonstrate the final product. They should talk about the process they used to get to the final solution, and also about why the user will want to use their solution.
Expected learning	Students will be able to: 1. Explain why there is a need to conserve water and give a rationale for their project (Science). 2. Communicate their solution to an audience and justify their design choices (Technologies). 3. Use defined success criteria to evaluate the effectiveness of their solution (Technologies).

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	4. Reflect on the design process and determine what worked well and what could be improved (Technologies).
Equipment required	**For the class:** Nil
	For the students: Materials to make cards or thank you letters
Preparation	**Part 1:** • Provide access to a collaborative online presentation app such as *Google Slides* or *Microsoft Office 365 PowerPoint*. **Part 2:** • Ensure students have access to the success criteria they made for their own project during *Activity 3, Part 3.* **Part 3:** • Print or provide digital access to *Student activity sheet 4.1: Peer evaluation* and *Student activity sheet 4.2: Self-evaluation*. **Part 4:** • *Print or provide digital access to Student activity sheet 1.0: Journal checklist*). **Part 5:** • Provide materials to make thank you cards if this idea is used.
Activity parts	**Part 1: Presentation of solutions** Students design a digital presentation using a collaborative presentation app such as *Google Slides* or *Microsoft Office 365 PowerPoint* to present their final solution to the class or other invitees. The following guidelines have been devised to encourage students to effectively report on the solution they have designed and to present in front of their peers: • No more than five slides following a title slide • Four dot points per slide (maximum – encourage less) • Four words per dot point (maximum – encourage less) • Each group must present their slides to the class.

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Other students should write down at least one question they can ask each student group. The teacher picks a few students to ask their question to the groups. If students do not know the answer they should be encouraged to say, 'I don't know, I'll find out' rather than fumble their way through a mistaken answer.

Students should add a link or embed their presentation in their electronic journal. Alternatively, they could print a copy and paste it into their journal.

To increase motivation, it may be worthwhile selecting the best presentation to give to a representative of Water Corporation.

Additional learning opportunity

Students complete a peer assessment to evaluate each solution.

Part 2: Project evaluation

Collect and collate evidence to determine the success of the project. Students should use the success criteria they created in *Activity 3, Part 3*.

Groups need to determine if their solution meets the success criteria developed in *Parts 3* and *4* of *Activity 3*.

Students record the following in their journals:

- Did our solution meet the success criteria? If so, was the solution a success according to the success criteria that were established earlier in the module?
- To what extent was it successful?
- Why was the solution successful, or not?
- Given more time and resources what would you do differently? Why?

Part 3: Group, peer and self-assessment

Teachers can use the suggestions below or may wish to use the standard assessment tools *Student activity sheet 4.1: Peer evaluation* and *Student activity sheet 4.2: Self-evaluation*.

Group assessment

Answer the following questions about your group:

- What did your group do well during this project?

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- What could your group have improved on?
- Was there a difference between how your group worked at the beginning and end of the project? How so?
- Comparing yourselves with the other groups, what score would you give your group out of 10. Why?

Peer assessment

Answer the following questions for each person in your group:

- What is this person's greatest attribute (or attributes) to the group?
- What could this person do to better contribute to the group?
- If you were to provide a score out of 10 for this person for this project, what would you give them? Justify your answer.
- Write an affirmation for this person.

Self-assessment

Answer the following questions about yourself:

- What was the greatest capability I brought to the group?
- What could I have done better to contribute more to the group?
- If you were to give yourself a score out of 10 for this project, what would you give yourself? Justify your answer.
- Write an affirmation for yourself.

Part 4: Completion and submission of journal

Students collect and collate any additional material for their journal using *Student activity sheet 1.0: Journal checklist* to ensure they have submitted all items.

Part 5: Celebrating success (Optional)

Students write an entry for the school newsletter/local paper or prepare an item for the next school assembly. Take photos to include in the entry. Students write thank you notes/cards to the required people for their own work. This could be opportunity to collaborate with the students' English teachers.

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Resource sheets	*Student activity sheet 1.0: Journal checklist* *Student activity sheet 4.1: Peer evaluation* *Student activity sheet 4.2: Self-evaluation*
Digital resources	Nil

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Appendix 1A: Links to the Western Australian Curriculum

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

WATER GAMES Links to the Western Australian Curriculum	ACTIVITY			
	1	**2**	**3**	**4**
SCIENCE				
SCIENCE UNDERSTANDING				
Chemical sciences: Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)		●		
Earth and space sciences: Some of Earth's resource are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)		●		
Earth and space sciences: Water is an important resources that cycles through the environment (ACSSU222)		●		
SCIENCE INQUIRY SKILLS				
Processing and analyzing data and information: Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)		●		

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WATER GAMES Links to the Western Australian Curriculum	ACTIVITY			
	1	**2**	**3**	**4**
DESIGN AND TECHNOLOGIES				
KNOWLEDGE AND UNDERSTANDING				
Materials and technologies specialisations: Material and technology decisions and processes influence the selection and combination of materials, systems, components, tools and equipment (ACTDEK034)		●	●	
PROCESS AND PRODUCTION SKILLS				
Designing: Design, develop, review and communicate design ideas, plans and processes within a given context, using a range of techniques, appropriate technical terms and technology (WATPPS41)				●
Evaluating: Independently apply given contextual criteria to evaluate design processes and solutions (WATPPS44)			●	
Collaborating and managing: Work independently, and collaboratively when required, to plan, develop and communicate ideas and information when using management processes (WATPPS45)				●
DESIGN AND TECHNOLOGIES				
PROCESS AND PRODUCTION SKILLS				
Collecting, managing and analyzing data: Create information using relevant software, and create data to model objects and/or events (ACTDIP026)		●		
Digital implementation: Design the user experience of a digital system (ACTDIP028)			●	

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WATER GAMES	ACTIVITY			
Links to the Western Australian Curriculum	1	2	3	4
MATHEMATICS				
NUMBER AND ALGEBRA				
Real Numbers: Multiply and divide fractions and decimals using efficient written strategies and digital technologies (ACMNA154)		●		
Real Numbers: Round decimals to a specified number of decimal places (ACMNA156)		●		
Real Numbers: Connect fractions, decimals and percentages and carry out simple conversions (ACMNA157		●		
Real Numbers: Find percentages of quantities and express one quantity as a percentage of another, with and without digital technologies (ACMNA158)		●		
Real Numbers: Recognise and solve problems involving simple ratios (ACMNA173)		●		
MEASUREMENT AND GEOMETRY				
Units of measurement: Calculate volumes of rectangular prisms (ACMMG160)		●		
STATISTICS AND PROBABILITY				
Data representation and interpretation: Identify and investigate issues involving numerical data collected from primary and secondary sources (ACMSP169)		●		
Data representation and interpretation: Calculate mean, median, mode and range for sets of data. Interpret these statistics in the context of data (ACMSP171)		●		
Data representation and interpretation: Describe and interpret data displays using median, mean and range (ACMSP172)		●		

Further information about assessment and reporting in the Western Australian Curriculum can be found at: *https://k10outline.scsa.wa.edu.au/home curriculum-browser/technologies/technologies-overview/ways-of-assessing*

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Appendix 1B: Mathematics proficiency strands

Key ideas

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

Understanding

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

Fluency

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

Problem-solving

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

Reasoning

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

Source:

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

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Appendix 2: General capabilities continuums

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

Information and communication technology (ICT) capability learning continuum

Sub-element	Typically by the end of Year 6	Typically by the end of Year 8	Typically by the end of Year 10
Create with ICT **Generate ideas, plans and processes**	use ICT effectively to record ideas, represent thinking and plan solutions	use appropriate ICT to collaboratively generate ideas and develop plans	select and use ICT to articulate ideas and concepts, and plan the development of complex solutions
Create with ICT **Generate solutions to challenges and learning area tasks**	independently or collaboratively create and modify digital solutions, creative outputs or data representation/transformation for particular audiences and purposes	design and modify simple digital solutions, or multimodal creative outputs or data transformations for particular audiences and purposes following recognised conventions	design, modify and manage complex digital solutions, or multimodal creative outputs or data transformations for a range of audiences and purposes
Communicating with ICT **Collaborate, share and exchange**	select and use appropriate ICT tools safely to share and exchange information and to safely collaborate with others	select and use appropriate ICT tools safely to lead groups in sharing and exchanging information, and taking part in online projects or active collaborations with appropriate global audiences	select and use a range of ICT tools efficiently and safely to share and exchange information, and to collaboratively and purposefully construct knowledge

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Critical and creative thinking learning continuum

Sub-element	Typically by the end of Year 6	Typically by the end of Year 8	Typically by the end of Year 10
Inquiring – identifying, exploring and organising information and ideas **Organise and process information**	analyse, condense and combine relevant information from multiple sources	critically analyse information and evidence according to criteria such as validity and relevance	critically analyse independently sourced information to determine bias and reliability
Generating ideas, possibilities and actions **Imagine possibilities and connect ideas**	combine ideas in a variety of ways and from a range of sources to create new possibilities	draw parallels between known and new ideas to create new ways of achieving goals	create and connect complex ideas using imagery, analogies and symbolism
Generating ideas, possibilities and actions **Seek solutions and put ideas into action**	assess and test options to identify the most effective solution and to put ideas into action	predict possibilities, and identify and test consequences when seeking solutions and putting ideas into action	assess risks and explain contingencies, taking account of a range of perspectives, when seeking solutions and putting complex ideas into action
Reflecting on thinking and processes **Transfer knowledge into new contexts**	apply knowledge gained from one context to another unrelated context and identify new meaning	justify reasons for decisions when transferring information to similar and different contexts	identify, plan and justify the transfer of knowledge to new contexts

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Personal and social capability learning continuum

Sub-element	Typically by the end of Year 6	Typically by the end of Year 8	Typically by the end of Year 10
Social management **Work collaboratively**	contribute to groups and teams, suggesting improvements in methods used for group investigations and projects	assess the extent to which individual roles and responsibilities enhance group cohesion and the achievement of personal and group objectives	critique their ability to devise and enact strategies for working in diverse teams, drawing on the skills and contributions of team members to complete complex tasks
Social management **Negotiate and resolve conflict**	identify causes and effects of conflict, and practise different strategies to diffuse or resolve conflict situations	assess the appropriateness of various conflict resolution strategies in a range of social and work-related situations	generate, apply and evaluate strategies such as active listening, mediation and negotiation to prevent and resolve interpersonal problems and conflicts
Social management **Develop leadership skills**	initiate or help to organise group activities that address a common need	plan school and community projects, applying effective problem-solving and team-building strategies, and making the most of available resources to achieve goals	propose, implement and monitor strategies to address needs prioritised at local, national, regional and global levels, and communicate these widely discuss the concept of leadership and identify situations where it is appropriate to adopt this role

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

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Appendix 3: Materials list

The following materials are required to complete this module.

Activity 2, Part 6 – Student activity sheet 2.6: Purifying contaminated water

- retort stand
- clamp
- filter funnel
- 250 ml beaker
- plastic spoon
- 2 x 100 ml beaker
- cotton wool
- sheet of newspaper
- washed beach sand
- small pebbles/blue metal/glass beads
- contaminated water – sawdust/straw/clay

Activity 2, Part 7* – Option 1: *Student activity sheet 2.7: Recovering pure water from a mixture

- safety glasses
- copper sulfate
- Liebig condenser
- anti-bumping beads
- cold water supply
- conical flask with stopper
- Bunsen burner and stand
- thermometer
- 100 ml beaker

***Activity 2, Part 7* – Option 2: Solar powered water desalination experiment**

- clear plastic rectangular containers with pre-drilled holes (2)
- plastic cups with pre-drilled holes (2)
- black construction paper, A4 size (3)
- white construction paper, A4 size (3)
- 25 ml graduated cylinder
- 800 ml graduated beaker
- thermometer
- modelling clay, 1 stick
- 5 ml funnels (2)
- flexible straws (2)
- steel washers, 7/16 size (2)
- rubber bands (2)
- plastic cling wrap
- tape
- salt
- water
- sunny location
- lab notebook

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Activity 2 – Teacher resource sheet 2.8: Investigation extension

- Plans of the school buildings to calculate the roof surface area or a plan view from *Google Earth* or similar.
- Access to a CAD system for students.
- If using, access to 3D Printer.

***Activity 2 Part 6*: Designing, making and testing a water filter**

If students choose to make their own water filter, the following notes outline the materials required for designing, making and testing a water filter.

This can be distributed to students, along with a dirty water sample.

Materials

- stocking material
- netting
- cotton wool
- sand
- gravel
- pebbles
- silk fabric
- sphagnum moss

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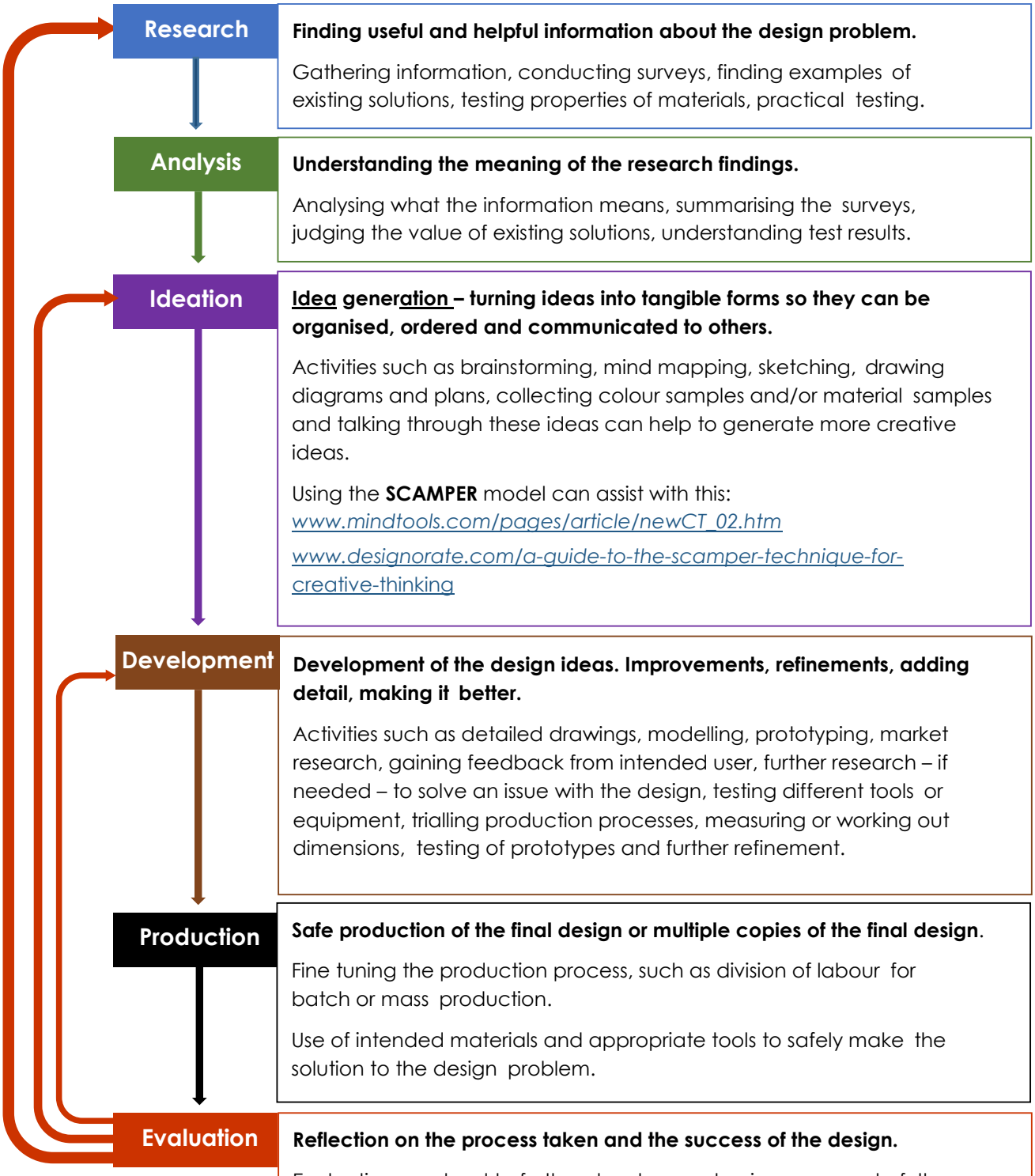
Appendix 4: Design process guide



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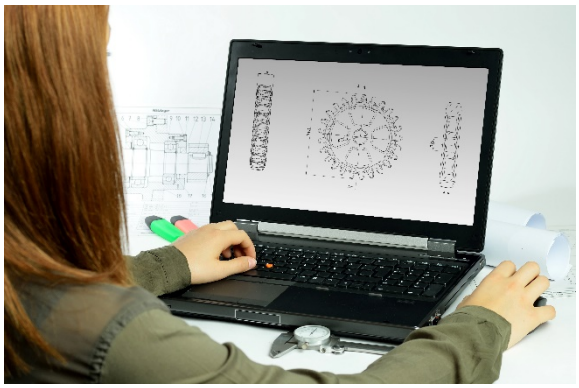
Appendix 4B: Drawing in the design process



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*
- Blog: *blog.tinkercad.com*
- Tutorials: *www.tinkercad.com/learn*
- Feature: Connects to 3D printing and laser cutting.

SketchUp

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

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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 Journaling.

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

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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.

Your name and group member's names or photographs	
An explanation of the problem you are solving	
Your notes from *Activity 1*	
Your notes from *Activity 2*	
Your notes from *Activity 3*	
Your notes from *Activity 4*	
Student activity sheet 2.1: Unit conversions	
Student activity sheet 2.2: Olympic swimming pools	
Infographic	
Student activity sheet 2.4: The water cycle	
Student activity sheet 2.5: Perth's water sources	
Student activity sheet 2.6: Purifying contaminated water	
Student activity sheet 4.1: Peer evaluation	
Student activity sheet 4.2: Self-evaluation	

Student activity sheet 1.0: Journal checklist	

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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.

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

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Appendix 8: Teacher resource sheet 1.2: Cooperative learning – 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>
<tr><td>Step 1</td><td>Cooperative groups
(of four students)</td><td colspan="2">1 2 3 4</td><td colspan="2">1 2 3 4</td></tr>
<tr><td>Step 2</td><td>Expert groups
(size equal to the number of groups)</td><td>1 1</td><td>2 2</td><td>3 3</td><td>4 4</td></tr>
<tr><td>Step 3</td><td>Cooperative groups
(of four students)</td><td colspan="2">1 2 3 4</td><td colspan="2">1 2 3 4</td></tr>
</table>

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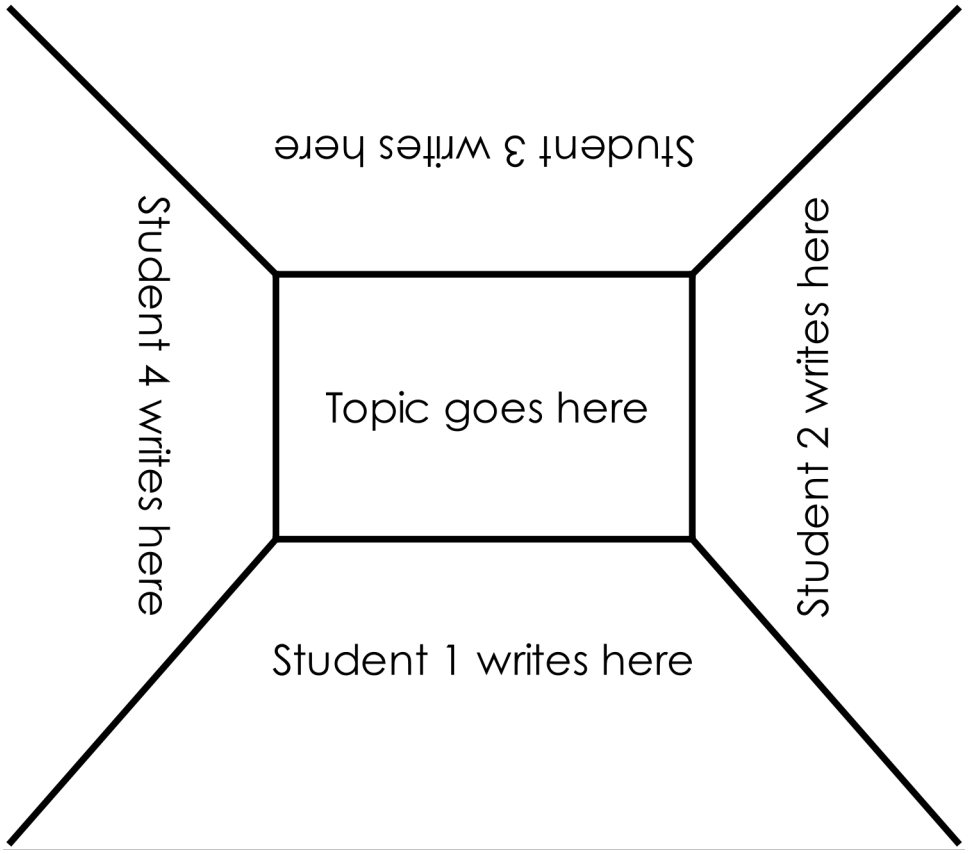
Appendix 9: Teacher resource sheet 1.3: Cooperative learning – Placemat

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.



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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.

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Appendix 11: Teacher resource sheet 1.5: Game mechanics

Links to the Western Australian Curriculum

Technologies | Digital Technologies | Processes and production skills | Digital implementation | Design the user experience of a digital system (ACTDIP028)

Game mechanics

Gamification is the application of elements of game playing to other activities to encourage engagement in those activities.

Examples of what is classified as gamification include:

- Exercise apps such as *Strava* show progress bars towards goals, badges for achieving certain goals, and challenges to compete against others.
- Teachers award certificates to students as they complete modules.
- *LinkedIn* shows a percentage completion of your profile and gives you a nickname for how much you have done to encourage you to complete more.

Game mechanics are elements of games that are used to encourage players to continue playing the game. These are applied to encourage people to continue with a task. In this module students will apply game mechanics to motivate their community to use a water saving strategy.

The Gamified UK website has a long list of game mechanics that can be used to generate possible ideas for the students' projects.

www.gamified.uk/user-types/gamification-mechanics-elements

Students may need some scaffolding to understand how to apply this to their project. It may be worthwhile to start with a game that all students know (eg the card game *Uno* or *Minecraft*) and identify which game mechanics are being used. For example, like many games, *Minecraft* uses the Free Spirit element of Exploration to give the opportunity for players to discover what they will find.

Once students have an understanding of how game mechanics can be applied, they should find ways to use them to motivate people to engage in water saving strategies. For example, players time how long they take to shower and there is a leader board for those who can take the shortest showers. Another example might be a digital tutorial on strategies to save water; where players must complete each strategy to level up, encouraging the user to build this into habitual action. Remember, the solution does not need to be a digital solution.

This activity could also be gamified to encourage students to generate many possible ideas!

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Appendix 12: Student activity sheet 2.1: Unit conversions

The Water Footprint Calculator is provided up by the Grace Communications Foundation to increase awareness and understanding of water usage.

www.watercalculator.org

The site is based in the United States and uses the non-metric measurement unit, the US gallon, to measure the amount of water used.

A US gallon is also different to the imperial unit gallon.

To convert US gallons to litres, the conversion rate of 1 US gallon = 3.785411784 litres can be used.

Task 1: Use the conversion rate above to convert the following amounts from US gallons to litres or kilolitres. Round your answers to two decimal places.

(a) 10 US gallons = _____ litres

(b) 150 US gallons = _____ litres

(c) 2 000 US gallons = _____ litres

(d) 47 000 US gallons = _____ kilolitres

Task 2: Use the conversion rate above to convert the following amounts from litres to US gallons. Round your answers to one decimal place.

(a) 500 L = _____ US gallons

(b) 3 500 L = _____ US gallons

(c) 40 kL = _____ US gallons

(d) 3 125 kL = _____ US gallons

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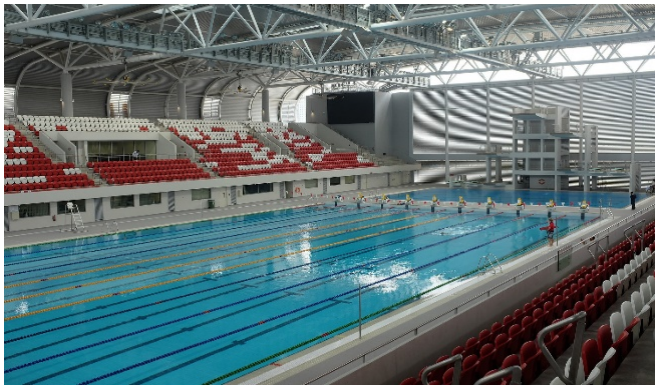
Appendix 13: Student activity sheet 2.2: Olympic swimming pools

Olympic swimming pools must be of a standard size. This size is length 50 m, width 25 m and depth a minimum of 2 m but recommended to be 3 m.

For this activity, we will use a depth of 2.5 m as this is an average of the possible depths.



Task 1: Use the dimensions given above, along with the formula for the volume of a rectangular prism, to calculate the volume of an Olympic swimming pool.

$$Volume(rectangular\ prism) = length \times width \times height$$

Task 2: Use the relationship 1 m^3 = 1 000 L = 1 kL to calculate the number of kilolitres of water required to fill an Olympic swimming pool.

Task 3: Convert the total water usage values of the class from litres into 'number of Olympic swimming pools'. Round your results accurate to one decimal place.

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Appendix 14: Teacher resource sheet 2.3: Infographics

Links to the Western Australian Curriculum

Technologies | Digital Technologies | Processes and production skills | Collecting, managing and analysing data | Create information using relevant software, and create data to model objects and/or events (ACTDIP026)

Science | Science inquiry skills | Processing and analysing data and information | Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)

Science | Science inquiry skills | Processing and analysing data and information | Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)

Mathematics | Statistics and probability | Data representation and interpretation | Describe and interpret data displays using median, mean and range (ACMSP172)

Infographics simplify complex information using eye-catching imagery and digestible pieces of data. They are increasingly being used in marketing to invoke an emotional response to the information provided.

Well-designed infographics:

- capture lots of reliable and interesting data
- focus on a topic of interest
- present information simply
- provide visuals of the data
- provide information succinctly
- provide obvious takeaways
- cite data sources
- are promoted and shared.

There are number of free programs that can be used to create infographics. Two examples of these are *Canva* and *Adobe Spark*.

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Canva

Canva is an app available through your web browser. There are a number of ready-to-use examples of good infographics that can be readily adapted by modifying the content and changing the fonts, background, images and colours. Students can also create infographics from scratch.

Adobe Spark Post

Adobe Spark Post allows students to create simple shareable posts aimed at social media. Through Adobe Spark there are three different options – Video, Post or Page. Students choose the Post option to create an infographic. Students enter the text and choose from a number of pre-existing templates. They can use the different menu options to change the layout, add pictures, change the colour palette, and more. Adobe Spark allows users to be creative and deliberately limits choices so the creations use elements and principles of design with suggestions of which colours, styles and fonts work together.

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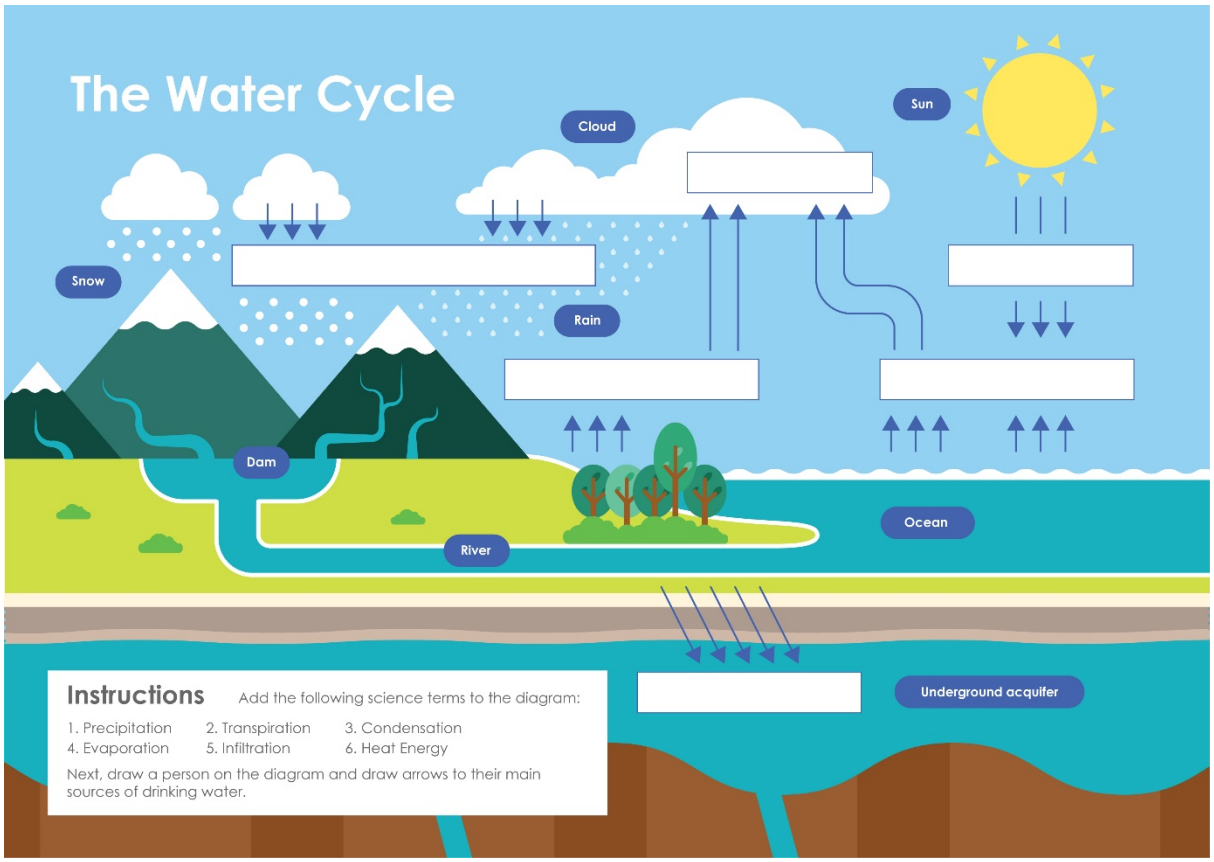
Appendix 15: Student activity sheet 2.4: The water cycle



Task 1:

Add the following terms to the diagram:

1. Precipitation	2. Transpiration	3. Condensation
4. Evaporation	5. Infiltration	6. Heat Energy

Task 2:

Draw a person on the diagram and draw arrows to their main sources of drinking water.

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Appendix 16: Student activity sheet 2.5: Perth's water sources

The Bureau of Meteorology has been collecting rainfall data since the late 19th century. Using these records, it is possible to identify changes in rainfall patterns over many years.

Table 1.

Perth monthly rainfall: A comparison of the long-term average with the average for 2014 to 2016.

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	**Total**
2014-2016	11	8	13	49	116	101	131	115	66	32	20	8	**670**
1876-2015	10	13	20	44	117	174	168	133	81	52	22	13	**839**

Source: Water Corporation website

Task 1:

Compare the rainfall data for 2014–2016 with the data for the long-term average of 1876–2015. Give two examples where the two sets of data differ.

Task 2:

What is the change in the average total rainfall between 1876–2015 and 2014–16?

Task 3:

Calculate and write this change as a percentage of the 1876–2015 total.

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Perth relies on three main sources of drinking water: dams, groundwater and water from desalination plants. Analyse the data in Table 2 detailing Perth water sources over the past 20 years.

Table 2.

Volumes of water from various sources between 1995 and 2015 (Megalitres).

	Year				
Source	**1995**	**2000**	**2005**	**2010**	**2015**
Dams	132 445	115 150	107 381	163 100	20 100
Groundwater	90 767	132 533	155 296	120 700	136 879
Desalination				47 980	138 645
Total	223 212	247 683	262 677	331 780	295 624

Source: Water Corporation Annual Reports

Notes:

1. Production of desalinated drinking water began in 2006, hence there are no records prior to 2010.

2. There are minor discrepancies in the way that this data is collected each year. For example, some south west dams are included in some years and not others.

Task 4:

What is the percentage increase in the volume of water used in Perth between 1995 and 2015?

Task 5:

Why do you think more water is being used in Perth in 2015 compared to 1995?

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Task 6:

What percentage of water was sourced from dams in 1995 and in 2015?

Task 7:

Water Corporation's *Fresh Water Thinking* video (2015) explains why we now have reduced run-off into our dams as a result of long-term reductions in rainfall *www.youtube.com/watch?annotation_id=annotation_2101379235&feature=iv&src_vid=QvtrlZ8XcLc&v=xm9O-TVo4KU*

Why have dams supplied less water to Perth in recent years?

Task 8:

What percentage of total water consumption was provided by desalination in 2015?

Task 9:

Find out why desalination was introduced in Western Australia?

Task 10:

Find out why Water Corporation is now recharging underground aquifers with treated wastewater?

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Appendix 17: Teacher resource sheet 2.6: Purifying contaminated water

Links to the Western Australian Curriculum

Science | Science understandings | Chemical sciences | Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)

Teacher notes

Student activity sheet 2.6 develops concepts relating to methods of separating mixtures and is set in the context of purifying contaminated water.

Each group of students will need a retort stand and clamps suitable to support a filter funnel (preferably plastic), a 250 mL beaker of contaminated water, a plastic spoon, two 100 ml beakers, a sheet of newspaper about 15 cm square, access to some washed beach sand, and some small pebbles or blue metal.

Make a supply of contaminated water so that it contains some floating particles such as sawdust or short lengths of straw, and some material like clay that will make the water cloudy when the water is stirred.

Students will make two filters. The first will be made from small pebbles, glass beads or blue metal chips which will only remove larger contaminants from the water. The second is made from washed beach sand. The beach sand needs to be thoroughly washed so that it does not add to the turbidity of the water. Given the smaller pores between the sand particles, the sand filter will remove both smaller and larger particles from the contaminated water.

Students will check the turbidity of the filtered water by placing newspaper under the beakers of filtered water and trying to read the print.

Safety note. Students should be reminded not to drink any of the water samples as they have been contaminated.

Sand filtration systems using gravity have been designed and developed for use in third world countries.

One charitable foundation, Trailblazers, installs these in countries like Cambodia so small communities can filter water from their contaminated sources to make drinking water. Information on this group is available at:

www.waterforcambodia.org

www.thetrailblazerfoundation.org/our-health-1.html

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Appendix 17A: Student activity sheet 2.6: Purifying contaminated water

Introduction

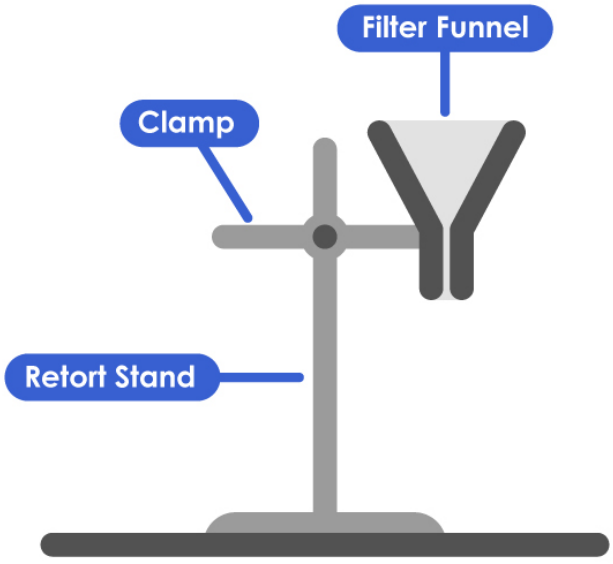
In remote areas where schemewater is not avaiolable and in developing countries, people are sometimes faced with drawing water from wells, rivers, lakes and by scooping away the soil to collect water that oozes to the surface from the water table. These sources of water are often contaminated and unsafe for human consumption. Contaminated water is a mixture of water and other things such as particles of soil and detritus which make the water cloudy or turbid. Other contaminants include salt dissolved in the water and disease-causing bacteria or protozoa. In Australia, engineers are developing ways of removing contaminants from water used by people and improving drinking water for livestock.

Your task is to construct two simple water filters to remove suspended particles from contaminated water to reduce its turbidity and to test their effectiveness.

Procedure

Safety note: Do not drink the water samples as they have been contaminated.

1. Set up a filter funnel on a retort stand with a clamp holding it.



2. Half fill the funnel with small pebbles to make a filter bed. Stir your beaker of contaminated water and then pour about 50 ml through your filter bed and collect the filtered water in a 100 ml beaker. What contaminants were trapped by the pebbles?

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3. Empty the pebbles from the funnel, plug the bottom with a small wad of cotton wool and then half fill the funnel with clean sand. Stir your beaker of contaminated water and then pour about 50 ml of contaminated water through your filter bed and collect the filtered water in a 100 ml beaker. What contaminants were trapped by the sand?

4. Compare the two samples of filtered water by placing the beakers on a sheet of newspaper. How cloudy (turbid) is the water? Can you read the newspaper print under both samples? How do they compare?

Discussion

1. What types of material were removed from the contaminated water by the two types of water filters? How is this related to the size of particles used to make the filter?

2. How effective were the two filters in reducing the turbidity of the water? What evidence do you have to claim that one filter was more effective than another?

3. Would your filters remove dissolved material like salt from the contaminated water? Why/why not?

4. Would your filters remove bacteria and protozoa from the contaminated water? Why/why not?

5. What advice would you give to an engineer who was designing a simple water filter made from low-cost materials that could be used to reduce contamination in water?

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Appendix 18: Teacher resource sheet 2.7: Recovering pure water from a mixture

Links to the Western Australian Curriculum

Science | Science understandings | Chemical sciences | Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)

Introduction

The Year 7 Science curriculum explores methods of separating pure substances from mixtures, including separating solvents, such as water, from solutions. This activity provides an opportunity to introduce the Liebig condenser through a demonstration, develop students' understanding of the particulate nature of evaporation and condensation, and then consider the design of solar stills used in emergency situations, off-the-grid living and in developing countries.

Safety notes

Copper sulfate is a heavy metal poison and should be treated with care. Always wear safety glasses and avoid contact with the skin. Copper sulfate solution is not to be disposed of down the sink as it will contaminate the environment. If you wish to avoid the issues around copper sulfate, any coloured liquid such as food dye can be used as a substitute.

Procedure for the demonstration

1. Set up the Liebig condenser as shown in the diagram, with about 30 mL of copper sulfate solution and some anti-bumping beads in the flask.

2. Connect the apparatus to a cold water supply and run a slow flow of water through the apparatus.

3. Heat the flask of copper sulfate solution until it boils, then adjust the flame to keep it boiling gently.

4. Read the thermometer as water vapour moves past it. It should be 100°C. This is the best test for pure water.

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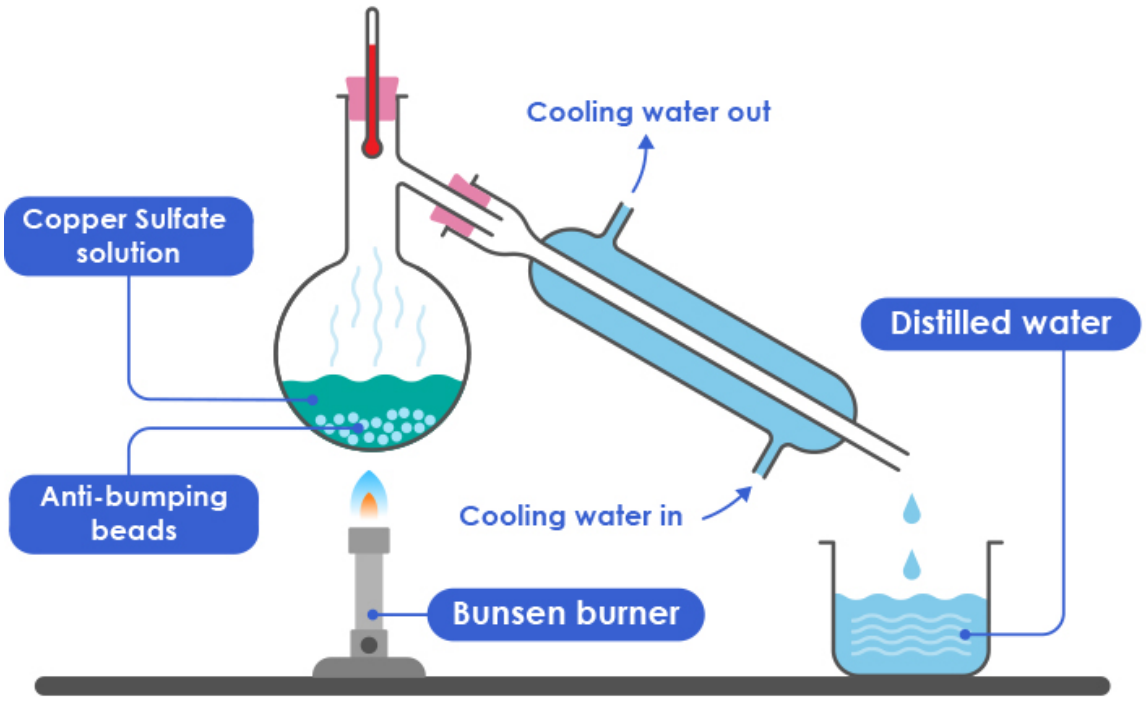

Discussion prompt questions

1. Identify each part of the apparatus and ask students to explain the role each part plays (eg What is the purpose of the water flowing through the apparatus?).
2. Where does evaporation and condensation occur within the apparatus?

At this point it would be helpful to show a simulation of evaporation and condensation at the particulate level.

3. What colour is the solution in the flask? What is the colour of the liquid in the beaker? Why are they different?
4. What is the temperature reading on the thermometer? What substance is flowing past the thermometer? How do you know it is water vapour?
5. Is this an environmentally sustainable way of making pure water? Why? …*because*…

Application of distillation principles to the design of solar stills

There are many examples of how the principles of evaporation and condensation have been applied in practical ways to build simple solar stills for extracting drinking water from contaminated water. These designs often use repurposed/recycled materials and the stills have been used in emergency situations and in developing countries.

Challenge students to find an image or diagram of one of these solar stills (using *a search engine*) and to provide a critique of the design drawing on scientific principles.

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Appendix 19: Teacher resource sheet 2.8: Investigation extension

Links to the Western Australian Curriculum

Technologies | Design and Technologies | Knowledge and understanding | Materials and technologies specialisations | Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)

Science | Science understanding | Earth and space sciences |Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)

Mathematics | Measurement and geometry | Using units of measurement | Calculate volumes of rectangular prisms (ACMMG160)

Water capture and reuse – Rainwater tank design

Show the video *Rainwater and Rainwater tanks* (Savewater! Alliance, 2012) youtu.be/aXthXDhJPj8

- The video explains that for every square metre of roof space, 1 mm of rainfall will equal 1 litre of rainwater. Ask students to prove why this is so (rectangular prism). Alternatively, this activity could be done before showing the video.
- The video talks about the rainwater tank needing to hold at least four weeks' worth of water in the summer period. Using the water footprint calculations from *Activity 2*, ask students to calculate the size of the water tank their family would need. What dimensions could this be as a rectangular prism?

Design a rainwater tank for the school

In groups, students design a rainwater tank for one of the buildings at the school.

- Choose a building at school.
- After determining the necessary measurements, calculate (if plans are available) or estimate the surface area of the roof.
- Determine the monthly rainfall in the school's location.
- Determine the materials required.
- Calculate the dimensions of a rectangular tank required to collect and store the water.
- The video talks about some of the other considerations (gutters, downpipes, plumbing to toilets, space available, run off) that may be included.
- If students wish to draw their design digitally they could use software such as *SketchUp* or *Tinkercad*. Support for using these can be found in the *Drawing in the design process* resource.

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Students present their findings to the other groups. They should listen for ideas they have missed or could change and document these ideas for improving their design in their journal. Use this as a way to encourage students to think about the design process as a cyclical process.

Groups re-design their rainwater tanks based on good ideas from the other groups. Base this redesign on questions such as:

- How would you make your design better?
- What else will you need to include?
- What needs to be changed? Why?

Additional activity

Students put together a report to the School Board, P&C or Executive team of the financial viability of installing rainwater tanks at their school. Students can put together a cost-benefit analysis and calculate how many years it will take for the tanks to become a profitable venture.

Note: Given the high costs of rainwater tanks, the relatively low cost of scheme water and the long periods between rainfall in Perth, this option is possibly financially unviable. Students could then consider the ethical question of whether saving water has a higher value than a monetary one.

Additional challenges

Here are some optional additional challenges to get students thinking more broadly. They are worthwhile additions to the task to reinvigorate students creative ideas if they are struggling to progress.

- Ask students if it is really possible to survive in the desert with a tarp stretched over a hole in the ground.
- Ask them to invent a method to transport water efficiently from a waterhole to a camp each day like so many people in developing countries have to do.
- Ask how they could cheaply stop evaporation from a storage pond or dam.

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Appendix 20: Teacher resource sheet 2.9: Water footprint – Class spreadsheet template 1

Student Number		Student 1	Student 2	Student 3
Student Name	Class To			
Indoor Water				
Shower	75	40	35	
Bathtub	19	9	10	
Bathroom Sink	116	40	76	
Toilet	55	25	30	
Kitchen Sink	110	65	45	
Dishes	12	4	8	
Laundry	10	7	3	
Greywater System	12	0	12	
Indoor Total	409	190	219	0
Outdoor Water				
Lawn and Garden	173	83	90	
Rain Barrel	0	0	0	
Swimming Pool	55	21	34	
Car Washing	0	0	0	
Outdoor Total	228	104	124	0
Virtual Water				
Driving	0	0	0	
Electricity	0	0	0	
Shopping Habits	2666	1166	1500	
Paper	-78	-2	-76	
Plastic	-86	-6	-80	
Bottles and Cans	-6	-1	-5	
Fabrics	-5	-5	0	
Diet	4023	1989	2034	
Pet Food	181	92	89	
Virtual Total	6695	3233	3462	0
Student Daily Total	7332	3527	3805	0
Students Yearly Total	2676180	1287355	1388825	0

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Appendix 21: Teacher resource sheet 2.9: Water footprint – Class spreadsheet template 2

Student Number	Class Total	Student 1	Student 2	Student 3
Student Name		0	0	0
Indoor Water				
Shower	**284**	151	132	0
Bathtub	**72**	34	38	0
Bathroom Sink	**439**	151	288	0
Toilet	**208**	95	114	0
Kitchen Sink	**416**	246	170	0
Dishes	**45**	15	30	0
Laundry	**41**	26	15	0
Greywater System	**45**	0	45	0
Indoor Total	**1552**	**719**	**833**	**0**
Outdoor Water				
Lawn and Garden	**655**	314	341	0
Rain Barrel	**0**	0	0	0
Swimming Pool	**208**	79	129	0
Car Washing	**0**	0	0	0
Outdoor Total	**863**	**394**	**469**	**0**
Virtual Water				
Driving	**0**	0	0	0
Electricity	**0**	0	0	0
Shopping Habits	**10092**	4414	5678	0
Paper	**-295**	-8	-288	0
Plastic	**-326**	-23	-303	0
Bottles and Cans	**-23**	-4	-19	0
Fabrics	**-19**	-19	0	0
Diet	**15229**	7529	7700	0
Pet Food	**685**	348	337	0
Virtual Total	**25343**	**12238**	**13105**	**0**
Student Daily Total	**27758**	**13351**	**14407**	**0**
Student Yearly Total	**10131769**	**4873166**	**5258602**	**0**

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Appendix 22: Teacher resource sheet 2.9: Water footprint – Class spreadsheet template 3

Student Number	Class Total	Student 1	Student 2	Student 3
Student Name		0	0	0
Indoor Water				
Shower	103626	55267	48359	0
Bathtub	26252	12435	13817	0
Bathroom Sink	160274	55267	105007	0
Toilet	75992	34542	41450	0
Kitchen Sink	151984	89809	62175	0
Dishes	16580	5527	11053	0
Laundry	15147	9672	5475	0
Greywater System	16580	0	16580	0
Indoor Total	566435	262518	303917	0
Outdoor Water				
Lawn and Garden	239030	114679	124351	0
Rain Barrel	0	0	0	0
Swimming Pool	75992	29015	46977	0
Car Washing	0	0	0	0
Outdoor Total	315022	143694	171328	0
Virtual Water				
Driving	0	0	0	0
Electricity	0	0	0	0
Shopping Habits	3683545	1611033	2072512	0
Paper	-107771	-2763	-105007	0
Plastic	-118824	-8290	-110534	0
Bottles and Cans	-8290	-1382	-6908	0
Fabrics	-6908	-6908	0	0
Diet	5558477	2748151	2810326	0
Pet Food	250083	127114	122969	0
Virtual Total	9250312	4466954	4783358	0
Student Yearly Total	10131769	4873166	5258602	0

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Appendix 23: Student activity sheet 3.1: Prototype troubleshooting

Problem	Reason for the problem	Possible changes to your design to solve the problem

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Appendix 21: Alternative Activity 4A: Student showcase

Activity focus	Two activities are provided for *Activity 4*. Both are based around the *Evaluate and communicate* stage of the design process. Each emphasises different aspects and teachers should choose to do *Activity 4* or *4A*. The choice should be based on the desired learning, available time and expertise. *Alternative Activity 4A* is designed to develop students' project management skills and provide them with ownership of the Student Showcase event. This activity will also develop students' interpersonal and communication skills. The students' solutions will be showcased to other students, parents, teachers and special guests. Students will: • develop their event management skills by planning and running the student showcase event • design an invitation using a digital design tool • improve their interpersonal and communication skills by showcasing their work to the broader community • gather feedback on their solution for further improvement.
Background information	This activity is about more than showcasing students' work. It is about handing over responsibility to the class to make the showcase happen and encourage students to develop the skills required to organise and run an event of this scale. By owning the project, students will learn organisational skills, problem-solving skills, interpersonal skills and more. The more responsibility students have, the more they will gain from this activity. Therefore, the focus of the activity is on these skills rather than the content. The most important take away from this activity is not the end product, but the process students went through to get there.
Instructional procedures	The following activity is about using broader accountability to encourage students to achieve their best. By encouraging the wider community to become involved in the project, the students will realise they can have an impact and make lasting change.

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	This event should be planned at the start of the project and students should be reminded of its importance throughout the module's duration. The showcase should be promoted by the teacher as an opportunity for students to expand the sphere of influence for their project idea and think beyond their own horizon. The activity brings together all the groups to work closely together to achieve a class goal. The teacher may want to discuss with the class about how on a project, big groups work together on different tasks to deliver an overall goal (ie establish small task groups who are responsible for specific tasks).
Expected learning	Students will be able to: 1. Work together in small groups to deliver a goal for the larger group. 2. Plan, organise and run an event. 3. Manage and prioritise tasks. 4. Create a digital publication that meets user requirements. 5. Review and reflect on a process to determine success.
Equipment required	**For the class:** Coloured circle stickers (or equivalent) Whiteboard and whiteboard markers Equipment for the event – room, desks, power cables, signage, refreshments etc Equipment for creating posters – either digital tools or artistic tools
	For the students: Suitable area to showcase student work Access to digital device, internet and apps Access to a colour printer to print invitations Device with required apps installed, logins setup
Preparation	It is recommended that teachers start conducting preparations for the showcase prior to the commencement of the project. While the students will be preparing for the event, the teacher will be required to coordinate the showcase behind the scenes.

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- Determine a suitable date for the event allowing students time to complete the project and book the showcase in the school calendar.
- Arrange for any formalities required to host the showcase at the school, including talking to the executive team, organising teacher reliefs, booking rooms/equipment, permission slips, pre-invitations to groups etc.
- Check and confirm a suitable area to showcase student work.
- Organise gifts for special guests.
- Order refreshments and food.

While the preparation for the showcase may seem overwhelming, remember the more of the showcase the teacher can allocate to students, the more they will learn. The teacher's role should be only for those things for which students cannot be held responsible.

Activity parts

Part 1: Plan the student showcase event

Create task cards using the questions below and allocate to each group. Delegate responsibility to the group for coordinating the area of responsibility and completing all associated tasks for the event. It is up to the teacher whether they want to provide an appropriate date and time for the event or whether they want to delegate this to the class.

The teacher may want to delegate a responsible person or have the class vote for a Project Manager or Events Coordinator who will work between all groups and make sure the event comes together. The teacher may also decide to allocate this to a group of students.

The teacher may want to use a task management tool to monitor the class management of the project. See the *Digital resources* section for a list of options. The benefits of using a task management tool are that tasks can be organised into groups, due dates allocated on the tasks, tasks assigned to a particular person and comments made on tasks.

Ideally, the Project Manager or Events Coordinator would be charged with creating a single project and inviting other students to collaborate, or else this job could be done by the teacher.

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Event management

- How long will the event run for?
- What will be the schedule for the event?
- When will refreshments be served?
- How long will guests require to view the projects and provide feedback?
- Who will MC the event? What will they say? Who needs to be thanked?
- What do the other groups need from each other? Who will coordinate this?
- Which task management tool will be used? Who will arrange this? Who will train the other groups?
- Who will set up and pack up the equipment used for the event?

Location

- In which room or area will the event take place?
- Where will the groups set up? How much space will they need? What specific requirements will they need?
- What equipment will be required?
- When will it be set up?
- How will it be set up?
- Who will set up?
- Who will pack up?
- How and when does equipment need to be returned?
- Will power be required?

Invitation and registration

- How will you contact people to invite them to the event (email, telephone or letter)? Who will do this?
- Which other organising groups may need to know who is coming? When will they need to know?
- Will the guests require name badges? Who will organise this?
- When will guests need to RSVP to the event? How much time will be required by the other groups to complete their tasks?
- How will guests RSVP to the event? Where will this information be stored?

Arrival on the day

- What signage will be required? From where can this be sourced?

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- Will the guests need to sign in on the day? How will they sign in?
- Will there be student representatives who will meet, greet and direct guests? Who will do this?

Refreshments

- Will refreshments be provided?
- How much money can be spent on refreshments?
- Will you provide drinks only or will food be provided?
- From where will you order the refreshments?
- Who will pick up the refreshments on the day?
- Who will set up the refreshments on the day?
- Will cutlery, crockery, cups and saucers, plastic cups be required?

Feedback forms and surveys (this could be done as a class activity)

- How will you collect data for each project? How will guests identify each project in the feedback?
- How will information be collected? Will data be collected electronically or with pen and paper?
- If data is used electronically, what tool will be used? A list of tools is provided in the *Digital resources* section. Which one is best for the data collection requirements?
- How will guests enter feedback? What equipment will be required?
- Who will provide feedback? Will students rate other groups?
- When will feedback be gathered?
- What feedback will be gathered? How will this feedback be gathered?
- What type of data are you hoping to generate? Will it be numerical data? Short answer questions?

Part 2: Each student creates an invitation to the Student Showcase using a design tool.

As a class, do a *Think–Pair–Share* activity as detailed in *Teacher resource sheet 1.4: Cooperative learning – Think, Pair, Share* to elicit the features and content of an invitation.

Write the answers on a whiteboard or in an electronic document for the class to see (this might make it easier to share later).

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As a class, discuss which of these elements will be required and which can be left out.

Content

- Event name
- Event description
- To _____, from _____
- Date and time
- Location
- RSVP (Students could investigate the meaning of this acronym)

Features

- Colour, Background, Fonts

Students use this information to create an invitation for the Student Showcase using a design tool (see *Digital resources*). Depending on the time available, the teacher could explore the Elements and Principles of Design (see *Digital resources*). Students will need to include all of the required elements discussed as a class.

Upon completion, each student will print out the invitation they have designed. These could also be displayed digitally. The invitation designs should be presented so that each student has access to them for voting. This could be done across tables or pinned to a wall.

Students vote for the best invitation. Each student is given five coloured stickers to vote for their favourite design. They are only allowed to stick at most, three on one invitation design. Encourage students to vote for the best design and not just vote for their friends. The winning design will be the one that will be sent to official invitees, including parents and guardians. The design with the most coloured circles after the voting process becomes the winning design.

Part 3: Create an invitation list

As a class, conduct a brainstorm of people the students could invite. Remind students that in order to make change happen, their idea needs traction with other people.

Below is a list of possible invitees, but don't let that limit the students' imagination.

- Parents or guardians
- Teachers or administration

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- P&C Committee, School board or School council representative
- Local council member
- Chamber of Commerce or Small Business Development Corporation representative
- Local members of Parliament
- Water Corporation representative
- Environment centre representative
- Indigenous leaders

The student group that has been delegated the task of coordinating the invitations should manage the sending of the invitations. The student group may want to accompany the invitation with a letter or email with additional information.

Part 4: Prepare project stall for event

Each group will be allocated a space for a stall to present their solution at the Student Showcase event. This activity provides them with the time that they need to prepare their project stall.

Students may like to create:

- posters or digital display including an explanation of how their solution works and estimates of how much water can be saved
- a customer-facing version of their solution
- a name for their solution
- a team logo for their business
- customised name badges (with logo).

Part 5: Manage the event

Students manage the event according to the agreed schedule. On the day, students will man their project stall and tell guests about their solution and how it works (the teacher may want to arrange for different students to man the stall two at a time so they can see the other group's stalls and provide them with feedback). Feedback on their project will be collected as per the event plan.

Resource sheets

Teacher resource sheet 1.4: Cooperative learning – Think, Pair, Share

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Digital resources	**Elements and principles of design** *Visual design elements and principles* (Wikipedia, 2017) *en.wikipedia.org/wiki/Visual_design_elements_and_principles* *Elements and Principles* (Atar Art 12, 2017) *atarart12.weebly.com/elements-and-principles.html* *Design elements and principles* (Canva, 2017) *designschool.canva.com/design-elements-principles*
	Digital design tools Adobe Spark *spark.adobe.com/* Canva *www.canva.com/create/cards/party-invitations/*
	Task management tools Asana *asana.com* Wunderlist *www.wunderlist.com/* Todoist *en.todoist.com/gmail*
	Survey and feedback tools Google Forms *www.google.com.au/forms/about/* Survey Monkey *www.surveymonkey.com* SurveyGizmo *www.surveygizmo.com/* Microsoft Forms forms.office.com/Pages/DesignPage.aspx

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Appendix 22: Student activity sheet 4.1: Peer evaluation

	Always	Usually	Sometimes	Rarely
Remains focused on tasks presented				
Completes set tasks to best of their ability				
Works independently without disrupting others				
Uses time well				
Cooperates effectively within the group				
Contributes to group discussions				
Shows respect and consideration for others				
Uses appropriate conflict resolution skills				
Comes to class prepared for activities				
Actively seeks and uses feedback				

Comments:

_____

_____

_____

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Appendix 23: Student activity sheet 4.2: Self-evaluation

	Always	Usually	Sometimes	Rarely
Remains focused on tasks presented				
Completes set tasks to best of their ability				
Works independently without disrupting others				
Uses time well				
Cooperates effectively within the group				
Contributes to group discussions				
Shows respect and consideration for others				
Uses appropriate conflict resolution skills				
Comes to class prepared for activities				
Actively seeks and uses feedback				

Comments:

_____

_____

_____

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Notes

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