

Western Treatment Plant

Micro-organisms at work

VELS Level 5

Strand/Domain	Dimensions
Discipline-based Learning/English	Writing
Discipline-based Learning/Science	Science knowledge and understanding
	Science at work

The pre-activities give students the necessary background to make a visit to the Western Treatment Plant more meaningful. These include providing students with an understanding of what substances enter the sewerage system (in particular laundry powders and detergents that contain salts and phosphates) by identifying mystery samples through testing. To gain an understanding of how gravity and pumping is used to carry sewage through pipes to the Eastern or Western Treatment Plants students investigate flow rates by posing scientific questions and designing their own investigations to answer them.

The post-activities elaborate on aspects of the sewage treatment process observed during the visit. Using the context of a job advertisement, students describe what they know about bacteria and their role in wastewater treatment. They measure the effect of aerating water on dissolved oxygen (DO) levels and relate the increased DO to the aeration stage of wastewater treatment and types of bacteria at either the Western Treatment Plant.

Pre-activity 1: Mystery Laundry Powders and Detergents

Focus

- Identify the main chemicals contained in laundry powders and detergents; measure salt content using an electrical conductivity (EC) meter; measure phosphates using a phosphate test kit or phosphate testing strips; measure the pH of solutions containing laundry powders and detergents.

Duration

- One period session and one double-period session (practical)

Preparation

- Prepare samples of four laundry powders or detergents labelled samples 1–4:
 - regular laundry powder to the rate of 5 g (1 teaspoon) to 1 L of water (equates to a standard wash for front loader). (Note: Use the rate 15 g per 1 L for top-loading laundry powders.)
 - regular laundry liquid to the rate of 5 mL to 1 L of water (equates to a standard wash for front loader). (Note: Use the rate 15 mL per 1 L for top-loading laundry detergents.)
 - low-sodium/low-phosphate laundry powder to the rate of 5 g (1 teaspoon) to 1 L of water (equates to a standard wash for front loader). (Note: Use the rate 15 g per 1 L for top-loading laundry powders.)
 - eco variety of laundry detergent to the rate of 5 mL to 1 L of water (equates to a standard wash for front loader). (Note: Use the rate 15 mL per 1 L for top-loading laundry detergents.)
- Containers or beakers for testing solutions of laundry powders and liquids
- Access to universal indicator and scale or data-logging equipment with pH probe
- Access to an EC meter, or data-logging equipment with EC probe
- Access to phosphate testing strips or (phosphate test kit to be conducted by the teacher).

Activity

- Discuss the range of substances and items that might end up in the sewerage system from households and factories. In particular, focus on laundry powders and detergents. Discuss reasons why

laundry powders and detergents are of concern in the treatment of wastewater. (See Science background on page 6 for further information.)

- Look at a selection of empty packaging for laundry powders and detergents in class or as a take-home task. Have students identify the key chemical constituents. Alert students to look for compounds that include chlorides, sodium, sulphates and phosphates.
- Students complete the following table using information supplied on the packaging or research using relevant websites (see References on page 6).

Chemical/substances identified in laundry powders and detergents	Why these chemicals are used in the laundry powders and detergents
sodium polyphosphate	softens water and removes soil

- Explain that you have made up solutions of four laundry products and that the students' task will be to carry out some tests to find out about the products and match each solution to its package using their results. Explain that, in each case, tap water will be measured and used as a reference.

Test 1: electrical conductivity

- Demonstrate how to measure the salinity of prepared solutions of laundry powders and detergents using an electrical conductivity (EC) meter. Use students from the class to assist in testing the water sample and the mystery laundry powders and detergents. Create a table of results to display the salt content measured in $\mu\text{S}/\text{cm}$ (micro-Siemens/centimetre). Interpret the results.

	Tap water	Sample 1	Sample 2	Sample 3	Sample 4
EC ($\mu\text{S}/\text{cm}$)					

- Pose and discuss the following questions:
 - Are there differences in EC measurements from the water sample and the solutions? What does this mean?
 - Is there a difference between EC measurements of mystery solutions? What does this mean?

Teacher tip

Schools that do not have access to an EC meter could contact their local council to enquire about the availability of Melbourne Water Waterwatch kits provided for local groups/schools to borrow.

Test 2: phosphates

- Demonstrate the use of a phosphate testing kit to roughly indicate phosphorus levels of the mystery solutions. Kits typically have a colour chart showing pre-determined concentrations, which can be used to best match the colour of each mystery solution. The corresponding concentration can be recorded.
- Phosphate test strips can be used to determine the presence or absence of phosphates. Select a range for measuring at least of 0–100 mg/L. (Up to 500 mg/L would be most suitable for testing laundry product solutions.)

	Tap water	Sample 1	Sample 2	Sample 3	Sample 4
phosphates (mg/L)					

Test 3: pH

- Demonstrate measuring the pH of water using a universal indicator, pH meter, or data-logging equipment and pH probe. Have students measure the pH of the mystery solutions. Use the universal indicator to determine the alkalinity or acidity of the solutions. Record results in a table.

	Tap water	Sample 1	Sample 2	Sample 3	Sample 4
pH					

- Pose and discuss the questions:
 - What does the pH indicate?
 - Why is a higher pH preferable for laundry products?

Results

- As a class, have students refer to their table of results and match the sample to the laundry product. Ask students to provide their reasoning for their suggested matches. Discuss the different claims on the packaging for example 'Low sodium/low phosphates'.

Conclusion

- Have students develop a series of messages about the use of laundry powders and detergents with consideration for the effects on the environment. (These could be refined after their Western Treatment Plant visit). For example:
 - Choose washing detergent with a low salt content.

- Concentrated detergents often contain much less salt than powdered varieties.
- Too much salt in the sewerage system means we may not be able to use the recycled water.
- These messages could be displayed in a place of prominence and linked to raising community awareness about wastewater through promoting relevant messages.
- Students create a list of questions related to wastewater treatment and laundry powders and detergents which could be discussed during their Western Treatment Plant visit. For example:
 - What happens to salts in the wastewater treatment?
 - Do phosphates and salts affect the bacteria that help in the treatment process?
 - Does a high or low pH affect the treatment process?
 - Do the salts in wastewater have to be reduced before being released to the environment?
 - Does the pH of wastewater have to be altered before being released to the environment?

Science background

- Almost half the salt in sewage that flows to the Western Treatment Plant comes from industry located to the west of Melbourne, and about one-quarter comes from households.
- Laundry powders and detergents may include phosphorus, sodium, boron, chloride and borax. Typically these laundry products contain inorganic compounds (salts) such as sodium tripolyphosphate, sodium carbonate, sodium silicate and sodium sulphate. Concentrates generally contain less sodium (salts) than regular laundry products because sodium is used as a filler in powdered laundry detergents. The amount of sodium in laundry detergents needs to be limited when the wastewater is to be discharged to vegetation or soil absorption areas, for example if the effluent is used as recycled water.
- Phosphates that enter waterways lead to increased nutrient levels which encourage the growth of algae and bacteria.
- The concentration of phosphate in the mystery laundry powder or detergent solution can be estimated by matching the colour produced to a colour wheel or colour chart for pre-determined concentrations, which can be found in a kit such as Visicolor Phosphate Testing kit or phosphate test strips. If using phosphate testing strips, select those that have a range up to at least 100 mg/L. Up to 300–400 mg/L is preferable, otherwise it will be difficult to distinguish between the mystery solutions.

- Acidic solutions have a pH of less than 7, while alkaline solutions have a pH of more than 7. Laundry powders are generally very alkaline with a pH above 8.5. A high pH is required to remove organic matter from clothes such as food stains and sweat. Greywater with a high pH, as a result of laundry products, may be harmful to both plants and the micro-organisms in the soil.

Safety note: Under no circumstances should students conduct tests on laundry grey water. Grey water can contain pathogens that may transmit disease. All laundry powder and detergent solution samples for testing must be prepared with clean water.

References

- Quality recycled water for the Werribee Plains: Salt-reduction strategy, Melbourne Water, www.melbournewater.com.au/content/library/water_recycling/western_region/quality_recycled_water_for_the_werribee_plains.pdf
- Laundry Products Research, Lanfax Labs, www.lanfaxlabs.com.au/laundry.htm
- CSIRO, Sources of Critical Contaminants in domestic wastewater, Smart Water Fund, www.smartwater.com.au/projects/round3/csiro/Documents/CSIRO_LiteratureReview_CriticalContaminants.pdf
- Choosing Laundry Detergents, City West Water, www.citywestwater.com.au/residents/choosing_laundry_detergents.aspx
- Electrical Conductivity, Waterwatch Australia, www.waterwatch.org.au/publications/module4/electrical.html
- Phosphate test strips: Macherey Nagel phosphate test strips Range 0–100 mg/L phosphate. Gradation 0–3–10–25–50–100, Apps Laboratories website, http://appslabs.com.au/index.php?main_page=index&cPath=410_40_280

Pre-activity 2: Investigate Flow Rates

Focus

- Design an investigation to gather data on flow rates of water flowing through tubing connected to a storage container. Relate the investigation to pipes that carry sewage through the sewerage system to the treatment plants.

Duration

- One double-period session

Preparation

- Prepare materials sufficient for each group of students:
 - plastic tubing of different diameters: 5 mm, 8 mm and 12 mm; 1L and 2L softdrink plastic bottles; and a bucket
 - graduated measuring jug
 - measuring device such as a stop watch
 - a low-melt glue gun to seal joins of tubing to plastic bottle
 - Teacher access to a cordless drill or similar to make a hole in the plastic bottle to fit the tubing.

Activity

- Explain that the sewerage system uses a combination of gravity and pumping to deliver sewage to the treatment plant. Gravity is the main force used to move the sewage in the sewer pipes but at different points along the pipes pumping stations may be needed to raise the sewage to a level where gravity can again take over.
- In one sewerage system the sewage is raised 16.5 m from its lowest point at one pumping station; it flows downhill and is then raised 27.5 m at the next pumping station. Enable students to get a sense of the height by comparing to heights of structures or trees in the school grounds. Using a fish tank pump and plastic tubing, demonstrate a pump in operation and relate this to the treatment plant by moving water uphill from a lower container to a higher container. Measure in seconds the time it takes to move 1 L up one metre. Calculate the flow rate in litres/second.
- Discuss how the water flows once it has been raised to its highest point. Pose the question, 'What factors affect how fast water flows through pipes?'. Introduce an investigation of flow rates in moving water from a storage container to another container through tubing. Use a variables grid, such as the one below, to brainstorm the aspects of the investigation that can change.

shape of storage container holding the water	quantity of water in the storage container	diameter of the tube
length of the tube	position of the tube on the storage container	inclination of the tube
flow rate		

- Identify the variable to be measured (which is the flow rate, litres/second). Explain that to ensure a fair test they should change one variable and keep all others the same. Use an example of changing the diameter of the tube, keeping all other variables the same and measuring any change in flow rate litres/second.
- Encourage students to come up with their own questions to investigate such as:
 - Does the inclination of the tube affect flow rate?
 - Does the diameter of the tube affect flow rate?
 - Does the quantity of water affect the flow rate?
 - Does the shape of the container affect flow rate?
- Guide students to turn their question into a hypothesis by making it an 'If, then' statement. As an example, if a question is 'Does the diameter of the tube affect flow rate', then the hypothesis would look something like: 'If the diameter of the tube affects flow rate then the flow rate should be faster for a tube with a larger diameter than that of a smaller diameter'.
- Provide students with Student worksheet: flow rate to design their investigation and record their results.
- Provide assistance to make holes in the plastic bottles to fit the plastic tubing. Supervise the use of the low-melt glue gun to seal the joins to prevent leakage.
- Discuss each group's investigation and results. Develop generalisations from the evidence gathered, for example, pipes of a larger diameter enable sewage to flow faster than pipes of a smaller diameter under the same pressure. Students could develop questions about flow rate and the diameter of pipes used around the treatment plant.

Extension activities

- Provide students with access to the following animation that shows changes in flow rates when the user changes the pipe dimensions: Animated Demonstration of Bernoulli's Principle, Pipe demo, on Mark Mitchell website, <http://home.earthlink.net/~mmc1919/venturi.html>

- Research the location of the treatment plant. Use topographic maps or Google Earth to compare the elevation with that of central Melbourne. Pose the question: 'Why do you think the elevation of the sewage treatment plant was a consideration when the site was chosen?'

Science background

- In a container of water, all the water pushes downwards, causing pressure on the water at the bottom. A greater quantity of water will cause a greater quantity of pressure pushing downwards; less water will result in less pressure. Refer to Animated Demonstration of Bernoulli's Principle, Pipe demo on Mark Mitchell website: <http://home.earthlink.net/~mmc1919/venturi.html>

Western Treatment Plant

- A system of pipes, sewers and drains built underground carry sewage from homes and factories to the sewage treatment plant. At the Western Treatment Plant a combination of gravity and pumping is used to move the sewage to the treatment plant. For most of the way it flows downwards but two pumping stations are used to pump the sewage upwards. The Brooklyn pumping station, which can pump 17,600 L of sewage a second, raises the sewage 16.5 m to the head of the trunk sewer, from where it runs downwards towards Hoppers Crossing. Another pumping station pumps the wastewater 27.5 m upwards, and from there it runs down to Werribee.

Eastern Treatment Plant

- A system of pipes, sewers and drains built underground carry sewage from homes and factories to the sewage treatment plant. The Eastern Treatment Plant has many small pumping stations that move sewage along and transfer it between systems within the plant. The pumps raise the sewage 17 metres from below ground to the highest point at the treatment plant.
- Generally the Eastern Treatment Plant is lower in elevation than the locations which are the source of the sewage, however some suburbs near the Eastern Treatment Plant are at the same or a slightly lower elevation.

Post-activity

Activity 1: Helpful, Hardworking Bacteria wanted

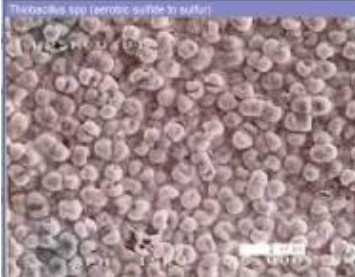


Focus

- Use the context of a job advertisement for students to describe what they know about bacteria and their role in wastewater treatment.

Activity

- Explain that bacteria are tiny organisms (micro-organisms) that are not visible to the naked eye and can only be seen with the aid of a microscope. Use the analogy that if you laid 1,000 bacteria end-to-end they would be equal to 1 mm.
- Ask students to recall what they found out about bacteria used in the wastewater treatment process. They may recall that in the treatment process:
 - there are two key types of bacteria; those that require oxygen and those that do not
 - one type of bacteria produces methane gas as it breaks down organic matter under anaerobic conditions (no oxygen)
 - another type of bacteria requires oxygen for respiration (aerobic conditions) as it breaks down organic matter
 - oxygen is added to the wastewater using mechanical beaters that mix together the wastewater and bacteria to form 'activated sludge' (Western Treatment Plant)
 - adding oxygen and mixing, speed up the treatment process as the oxygen-loving bacteria grow and reproduce and break down organic matter
 - bad odours are produced by anaerobic bacteria in the form of the gas hydrogen sulphide; these bacteria also produce methane and carbon dioxide
 - given a suitable environment and sufficient food, bacteria reproduce and multiply at a great rate
 - anaerobic bacteria take longer to break down organic matter than aerobic bacteria as they have a slower metabolism and get their energy from sulphates and nitrates
 - several different types of bacteria are used to remove nutrients from wastewater before it can be released back into the environment.
- Explain that the science ideas about bacteria that are incorporated into the job description must be accurate.

- Show examples of several job advertisements so that students are familiar with the format. List relevant headings to prompt students, such as employer, location, work environment, working conditions, job description and their role, skills required, work as a team/individually. Provide students with the Student worksheet: Job Advertisement Wastewater Treatment.
- Students may require access to the Melbourne Water website for information related to stages in the treatment that use bacteria to break down the organic matter. The Western Treatment Plant Explorer is a useful resource, http://education.melbournewater.com.au/content/sewage_and_recycling/western_treatment_plant/western_treatment_plant_explorer/western_treatment_plant_explorer.asp.
- Review the 'Lagoon system' section to find out how bacteria consume biodegradable matter in the wastewater.
- Select 'One of the three modern lagoon systems' to discover in more detail the role of bacteria, algae and zooplankton in the treatment process.

		
<p>In the 'Lagoon system' section, select 'Gallery' to view images of bacteria such as <i>Thiobacillus spp</i> (aerobic sulphide to sulphur)</p>	<p>Select the 'Anaerobic zone' section to view an image of anaerobic bacteria.</p>	<p>View a video of zooplankton that consume algae and bacteria.</p>

- Share students' completed job advertisements and discuss the science ideas presented.

Note: This task could be used for assessment purposes to assess student understanding of the role bacteria plays in the treatment of wastewater.

Extension activities

- Organise half the class to write the job advertisement and the other half of the class (after the advertisements have been completed) to respond to a job advertisement from the point of view of the bacteria.

- Use the context of a job advertisement to describe the role of algae and zooplankton in the wastewater treatment process.

Science background

- There are two main types of ponds used in sewage treatment, anaerobic (without oxygen) and aerobic (with oxygen). Anaerobic and aerobic ponds suit different types of bacteria – and the treatment plant needs both types of bacteria to break down the sewage. Under anaerobic conditions, bacteria produce strong, unpleasant smells and release greenhouse gases (methane).
- In the first pond, aerators pump oxygen into the water to reduce the unpleasant smells. In the remaining ponds, oxygen is available naturally because sewage is now exposed to the air, not enclosed in pipes or under covers. Natural aeration is provided by algae that photosynthesise and produce oxygen in the process. Algae take up nutrients including nitrogen and are then eaten by zooplankton.

Visit www.melbournewater.com.au/content/sewerage/western_treatment_plant/sewage_treatment_-_how_it_works_today.asp?bhcp=1

Post-activity 2: Getting Agitated

Focus

- Measure the effect of aerating water on dissolved oxygen (DO) levels. Relate the increased DO to the aeration stage of wastewater treatment and types of bacteria.

Activity

- Show a sample of tap water, measure its temperature and use a DO meter, or data-logging equipment with a DO probe to measure the level of DO. Explain that it is useful to measure temperature as the temperature affects the DO levels.
- Depending on the available resources, demonstrate or enable students to investigate the effect of aerating a sample of water. Two methods of aerating water are:
 - a pump and aquarium aerator stone
 - mechanically agitating the water, for example with a whisk or hand beater.
- Relate the two types of aeration used at Melbourne's two main treatment plants. The aerated sludge plants at the Eastern Treatment Plant and the 25W pond at Western Treatment Plant use aerators like the aerator stone; 55E at the Western Treatment Plant uses aerators similar to the hand beater.
- Measure the DO levels and temperature before and after aeration and record data in a table.
- Discuss the following:
 - What happens to the DO levels in the water as a result of the two methods of aeration?
 - What type of bacteria benefits from the aeration of wastewater?
 - Why is aeration a step in wastewater treatment?
- Students write a brief report about their investigation including their results and responses to questions, including images of the relevant section of the treatment plant to indicate where the process takes place.

Teacher tip

Schools that do not have access to a DO meter could contact their local council to enquire about the availability of Melbourne Water Waterwatch kits provided to local groups/schools to borrow.

Extended investigation

- Students design an investigation that measures the effect of adding dead plant material such as grass clippings or the leaves of an aquatic plant to a sample of water. Ideally the investigation can be carried over at least 1–2 weeks. Students set up a control for comparison. Students take measurements of temperature and DO levels.

Science background

- DO is the amount of oxygen gas that is dissolved in the water. DO is measured in milligrams per litre (mg/L). Aquatic organisms such as fish require at least 6 mg/L of DO in the water to survive.
- Organic wastes are the remains of any living or once-living organism. Organic waste is decomposed by bacteria; these bacteria remove DO from the water when they breathe. If more food (organic waste) is available for the bacteria, more bacteria will grow and use oxygen, and the DO concentration will drop.
- For information about measuring DO with a DO meter, refer to 'Dissolved oxygen' at www.waterwatch.org.au/publications/module4/oxygen.html#4.

Student worksheet: Flow Rate (pre-activity 2)

Introduction

- A system of pipes, sewers and drains built underground carry sewage from homes and factories to the sewage treatment plant. A combination of gravity and pumping is used to move the sewage to the treatment plant. For most of the way it flows downhill through these pipes.
- Consider the question: What factors affect how fast water flows through the pipes?
- Does the inclination of a pipe affect the flow? What about the diameter of the pipe, does that make a difference?
- Use a plastic softdrink bottle and plastic tubing as a starting point to design your own investigation.
- Ensure you design a fair test by only changing one variable.

Materials and equipment

- plastic tubing of different diameters: 5 mm, 8 mm and 12 mm
- 1 L and 2 L plastic soft drink bottles, and a bucket
- graduated measuring jug
- timing device such as a stopwatch
- a low-melt glue gun to seal joins of tubing to plastic bottle.

Hypothesis

My question to investigate:

Turn this into a hypothesis:

If

then

Controls

List the variables that may change in your investigation in the grid below:

Variable being measured is

Variable being changed is

Variables kept the same are

Procedure

Draw a labelled diagram of your investigation.

Observation and results

Create a table for your results.

Conclusion

Explain your findings based on your evidence.

Student worksheet: Job Advertisement - Wastewater Treatment (post-activity 1)

Introduction

- Bacteria are an important part of wastewater treatment.
- Create a job advertisement that describes the role of bacteria in the wastewater treatment process.

Employer

Location

Job description and role

About the work environment

Working conditions

Skills required

Working as a team

Conclusion

- In what ways are bacteria important in the wastewater treatment process?

Curriculum mapping

Strand/ Domain	Dimensions	Level	Standard
Discipline-based Learning/English	Writing	5	Produce, in print and electronic forms, texts for a variety of purposes, including speculating, hypothesising, persuading and reflecting.
Discipline-based Learning/Science	Science knowledge and understanding	5	<p>Explain the relationships, past and present, in living and non-living systems, in particular ecosystems, and human impact on these systems.</p> <p>Analyse what is needed for living things to survive, thrive or adapt, now and in the future</p> <p>Use the particle model to explain structure and properties of matter, chemical reactions and factors that influence rate.</p>
	Science at work	5	<p>Design investigations that include measurement, using standard laboratory instruments and equipment and methods to improve accuracy in measurement.</p> <p>Make systematic observations and interpret recorded data appropriately, according to the aims of the study.</p>

Connections to the Australian Curriculum

Australian Curriculum	Content strands/ sub-strand	Content descriptions
English	Literacy/ Creating texts	<p>Year 7</p> <p>Plan, draft and publish imaginative, informative and persuasive texts, selecting aspects of subject matter and particular language, visual, and audio features to convey information and ideas (ACELY1725)</p> <p>Year 8</p> <p>Create imaginative, informative and persuasive texts that raise issues, report events and advance opinions, using deliberate language and textual choices, and including digital elements as appropriate (ACELY1736)</p>
Science	Science Understanding/ Biological sciences	<p>Year 7</p> <p>There are differences within and between groups of organisms; classification helps organise this diversity (ACSSU111)</p> <p>Interactions between organisms, can be described in terms of food chains and food webs; human activity can affect these interactions (ACSSU112)</p> <p>Year 8</p> <p>Multi-cellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce (ACSSU150)</p>
	Science Understanding/ Chemical sciences	<p>Year 7</p> <p>Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)</p> <p>Year 8</p> <p>Differences between elements, compounds and mixtures can be described at a particle level. (ACSSU152)</p>
	Science Understanding/ Earth and space	<p>Year 7</p> <p>Water is an important resource that cycles through the</p>

sciences	environment (ACSSU222)
Science Understanding/ Physical sciences	Year 7 Earth's gravity pulls objects towards the centre of the Earth (ACSSU118)
Science Inquiry Skills/ Questioning and predicting	Years 7 and 8 Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)/ (ACSIS139)
Science Inquiry Skills/ Planning and conducting	In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS126)/ (ACSIS141)
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 , including using digital technologies as appropriate (ACSIS129)/ (ACSIS144) Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS130)/ (ACSIS145)
Science Inquiry Skills/ Evaluating	Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131)/ (ACSIS146)
Science Inquiry Skills/ Communicating	Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate. (ACSIS133)/ (ACSIS148)