Rugged robot waste collection

This activity focusses on the concept of responsible resource use and active citizenship through a practical local action of creating a waste management sorting system.

Students will design, test, and refine algorithms to solve a logistical problem requiring them to determine and categorise elements of waste based on recycling potential or the possibility for re-use. Their algorithms will program a robot (autonomous vehicle) to collect waste items and deliver them to appropriate centres. Their additional challenge will be to create the most energy efficient pathway – creating an Energy score.

Curriculum links

This activity is aligned with elements of the following learning areas. We encourage teachers to adapt the content to suit the needs of their students between Years 1 and Years 4. More curriculum details are provided in the supporting documents.

Digital Technologies	Sustainability Cross-curriculum priority	Mathematics

Required resources

You will need the following materials:

CSER Lending library kit (Rugged robot – 4 robots and 4 iPads supplied)

- Rugged robot (1 per group of students)
- iPad with Robot Turtle App (1 per group)
- Printed recycling cards (incl Recycling centres and sample waste type cards)
- Outdoor space with bins and waste items if available

Pre-requisite knowledge

Prior to this session, students would benefit from having experience with:

- playing games that involve locations and position
- giving and following simple directions to position themselves or objects
- the language of directions – left, right etc

Key terms

Algorithm: Precise description of the steps and decisions needed to solve a problem. Algorithms often involve iterative (repetitive) processes and can be represented, e.g. as flowcharts and pseudocode.

Pseudocode: English language statements that describe the steps in an algorithm in a clear, unambiguous way. It can be easily translated into code using a programming language.

[Australian Curriculum – Technologies Glossary]

Suggested steps

Whole group

Begin by talking about how important it is to keep our world clean and not to waste resources. Discuss the student's awareness and knowledge of the variety of rubbish bins in their school, home and public places around them. Walk around the school and local area, if possible, and take note of waste collection opportunities. Discuss the types of bins that are available to dispose of school rubbish correctly.

- What types of bins are available?
- Do you know what goes in each bin?
- Are there any items that don't suit any bin?
- Does all waste need to go in a bin, or can some things be re-used instead?

This activity is linked with Sustainable Development Goal 12 (SDG 12), which is about making cities and human settlements inclusive, safe, resilient and sustainable.

Setting the scene

Your team works for a new recycling logistics company and must program a rugged robot to collect scattered waste in a regional town or school. Rugged robot's mission is to locate rubbish, determine where it should go and show it the way.

Additional challenge

Design the most efficient solution to reduce energy costs. Students could calculate an energy score based on:

- Each individual instruction to the robot (step or line of code) will gain an energy score - the lower the score the better.
- Measure the distance the robot travels – the shorter the route the better. (This will require understanding that each robot movement is 20 cm)

Simulation environment

A large classroom grid map or playground space. Include a marked "Recycling centre" for each refuse type and possibly "Restricted zones" (e.g., a simulated puddle or uneven ground the robot must avoid).
As Rugged robot can make 45° turns, ensure that items are placed in positions that will require 45° and 90° turns.

Mathematics note: the measures of turn concept is formally introduced at Year 3

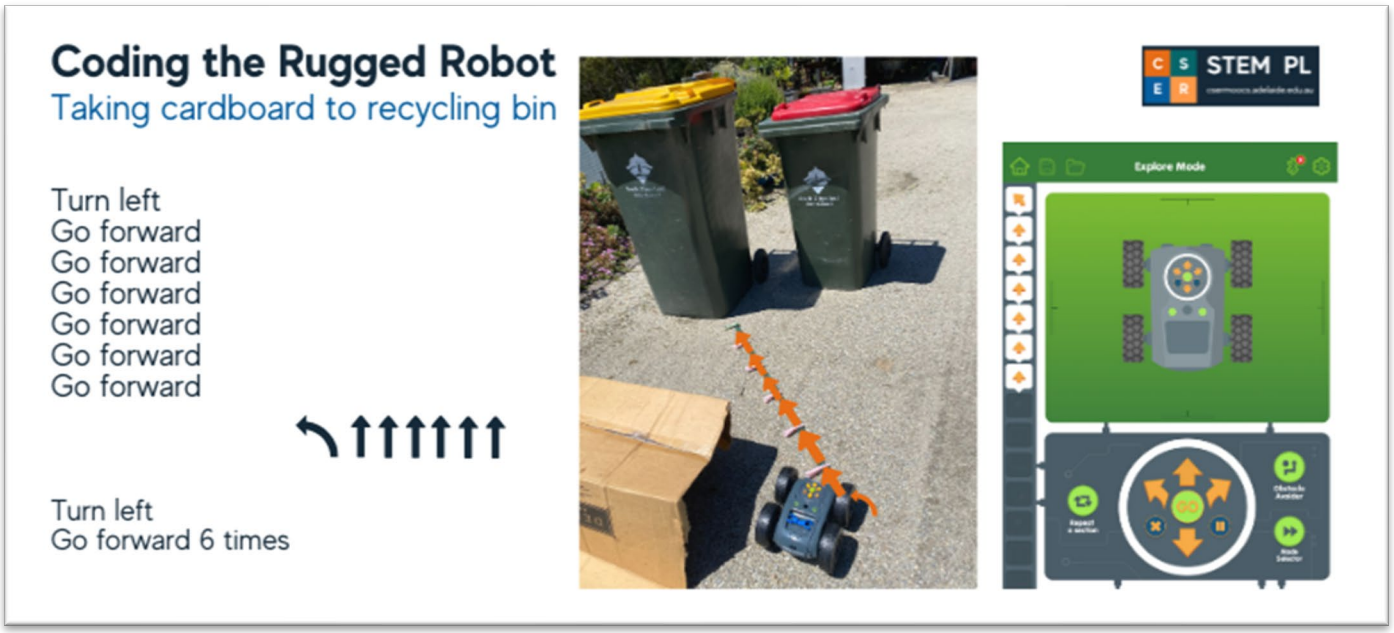
'A measurement of rotation from an initial starting position. A turn can be a fraction of a circle (quarter turn) or complete rotation (revolution). It can be directional (clockwise or anti-clockwise).
A quarter turn is the same as a right angle; a half a turn is greater than a right angle and is the same as 2 right angles; a three-quarter turn is greater than a right angle and is the same as 3 right angles' (Australian Curriculum)

Younger students using a Rugged robot could be encouraged to use the term 'right turn'.
Two right turns = a right angle or 90°.

Waste markers
Labelled cards representing different waste types (samples provided in supporting documents) and small tokens that can be collected and taken to the recycling centre in the Robot Turtle storage container. Providing the token for each piece of waste, allows the Rugged robot to carry it.

- Please note that in our sample cards, we have provided many examples of waste bins and many examples of waste. Select the examples that suit your context or create your own.
- If space allows, you could also set real props in outside spaces instead of using cards (see picture below)

Record keeping
Students can record their algorithm on coding sheets or use digital logs for planning the sequence of moves. You can see from the image below that students can prepare their codes in a variety of formats. They may use words (pseudocode) or symbols (arrows). Students might use whiteboards as they facilitate de-bugging (amending and improving their algorithms).

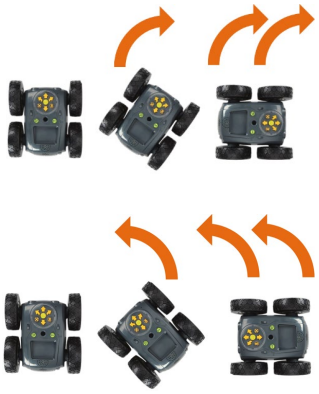
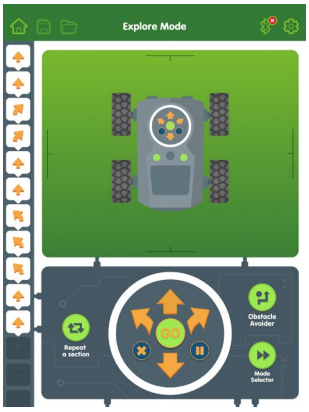


Map setup and analysis

Place the waste markers and restricted zones randomly across the grid map.

Establish the rules (or adapt and establish your own):

- Each group will be allocated one category of waste.
- The robot must identify and collect all waste of that category.
- The robot can only hold one piece of waste at a time before returning to the recycling centre to deposit it. (This forces multiple trips and complex path planning.)

Using the robot buttons		Using the App	
Forward - one 20 cm step forward Side arrow right - 45° turn to right Side arrow right (twice) - 90° turn to right Side arrow left - 45° turn to left Side arrow left (twice) - 90° turn to left Back arrow – one 20 cm move backward X – deletes program II – pauses motion for 1.5 secs		Using the Rugged Robot App, users can design the algorithm, including using the repeat function. Connect the robot via Bluetooth to the iPad. The app can retain up to 256 steps. The algorithm can be viewed before being run.	

Small group activity

Programming challenge – writing the algorithms

Each group must prioritise collecting one allocated waste material type. Students work in small teams to design the most efficient path sequence. Students:

- will gain an **Energy score** based on the number of steps taken to retrieve their items (the lower the score the better)
- will draft their code sequences on the planning sheets
- may use symbols, pseudocode or devise their own algorithm style
- should create plans (algorithms) that can be interpreted by other teams.

Measurement hint

Help students to visualise multiples of 20 cm by using tape or ribbon with pegs at 20 cm intervals.

Run and debug

Teams take turns running their code on the robot. If the robot enters a Restricted Zone or fails to follow the path, the team must stop, identify the bug, and revise their code (debugging). They track the total number of moves for the entire collection process (multiple trips).

Optimisation and documentation

Teams refine their code to reduce the total number of moves (or steps in their code). Once the most efficient path is found, students document their final code sequence e.g. a written list of steps and calculate their final "Energy Score" (Total steps used or distance travelled).

Does the algorithm work?
Students should be encouraged to test each other's algorithms to ensure they are accurate and to receive and implement feedback they receive.

Pose questions

Use these example open-ended questions to prompt student reflection, check for understanding, and encourage discussion to help students explain their thinking and build on each other's ideas.

- How could you check that your algorithm makes sense?
- What have you discovered about the turns the robot makes? How far does it go in one press? Two presses? When pressing a turn arrow, does the robot move forward?
- Can you represent your algorithm in a variety of ways?
- Can you find more than one way to reach the same destination?

Why is this relevant? (Real world connections)

This activity directly reflects real-world applications in automation, environmental sustainability, and the logistics of waste management, showing students how technology can be used to address global challenges. Working in collaborative groups solving problems and applying computational thinking skills, students are developing transferable skills for other problems.

Assessment

Observation can be used to check students' ability to carry out tasks aligned to the Australian Curriculum. We have included some suggested questions for teachers to reflect on and to guide these observations.

Checking for understanding

- Were the students able to follow and describe an algorithm required to demonstrate the solution to the problem?
- Were they able to convert their pseudocode into an algorithm accurately?
- Were they able to debug their code if the robot didn't behave as expected?
- Did they use positional and directional language accurately?

For more assessment resources we recommend the Assessment resources on Digital Technologies Hub.

Sustainability resources on waste reduction and management	
Sustainability Victoria	Resource Smart Schools A How-To guide
ABC Education	Clips from the ABC documentary War on Waste presented by Craig Reucassel.
WWF Australia	Reduce, Reuse, Recycle Reduce, Reuse, Recycle - WWF-Australia | Reduce, Reuse, Recycle | WWF Australia
Australian Children's Education and Care Quality Authority	ACECQA War on Waste The war on waste in education and care | ACECQA
WA Waste Authority	Waste Sorted Schools –education resources Education resources | Waste Sorted Schools | Waste Authority WA

Supporting document

Recycling options We expect that classes may select 3 or 4 options for the activity

Option	Description	Possible contents
Paper & Cardboard (Green Bin)	This is the most common recycling stream. It should be kept clean and dry to ensure it can be processed.	**Office paper**, **newspapers**, **magazines**, **cardboard boxes** (flattened), and **manila folders**.
Plastic bottles & Containers	Check with your local council, as only certain numbers of plastics (e.g., 1, 2, 5) may be accepted.	**Water bottles**, **juice bottles**, **yogurt containers**, **takeaway food** and **milk bottles**.
Aluminium & steel cans	This is for metallic food and drink packaging. It's highly recyclable and saves a significant amount of energy compared to creating new metal. Ensure all contents are emptied and rinsed.	**Soft drink cans**, **food tins** (e.g., tuna, beans), and **empty aerosol cans** (must be empty).
Food organics (Worm farm/Compost)	This converts food scraps into nutrient-rich soil or worm castings for school gardens. It dramatically reduces the amount of waste sent to landfill.	**Fruit and vegetable scraps**, **tea bags**, **coffee grounds**, and small amounts of **paper towels**. **No meat or dairy.**
E-Waste (Electronic waste)	This is a specialised collection point for old electronic devices, which contain valuable materials and toxic substances that shouldn't go into general rubbish. These items often require a separate collection or service.	**Old phones**, **batteries** (in a separate, sealed container), **broken laptops**, **keyboards**, **power cords**, and **small printers**.
Soft plastics (e.g., REDcycle)	This program is for plastics that cannot be put in the regular recycling bin. It allows them to be bundled and dropped at a collection point (usually a supermarket) to be repurposed.	**Bread bags**, **cereal box liners**, **frozen vegetable bags**, **plastic shopping bags**, and **confectionary wrappers**.
Landfill	This is the place where things that cannot be recycled or reused must go. It is often buried to protect the environment from odours, disease and pests.	**Non-recyclable or re-useable items. Often products made of mixed materials.**
Green waste	General biodegradable organic garden waste material that can be processed, composted and sold as compost or wood chip.	**Trees, branches, leaves, plant clippings, palm fronds, grass clippings**

Supporting documents

Australian Curriculum

Sustainability is an over-arching theme and cross-curriculum priority and as such provides an excellent concept for exploring many learning areas. Curriculum connections resources in the Australian Curriculum, support the teaching and learning of interrelationships across various themes. The concepts of recycling and sustainability are strong in Food and Wellbeing, Outdoor Learning, and Food and Fibre, which includes considering sustainability solutions such as finding innovative uses for surplus and reducing waste.

Depending on teacher judgement and classroom requirements, this activity could be adjusted for students between Year 1 and Year 4.

Digital Technologies

Students learn to:

- follow and describe algorithms involving a sequence of steps, branching (decisions) and iteration (repetition) (AC9TDI2P02). (Years 1 & 2)
- follow and describe algorithms involving sequencing, comparison operators (branching) and iteration (AC9TDI4P02) (Years 3 & 4)

Mathematics

Students learn to:

- give and follow directions to move people and objects to different locations within a space (AC9M1SP02) (Year 1 Space)
- locate positions in two-dimensional representations of a familiar space; move positions by following directions and pathways (AC9M2SP02) (Year 2 Space)
- give and follow directions to move people and objects to different locations within a space (AC9M1SP02) (Year 1 Measurement)
- identify, describe and demonstrate quarter, half, three-quarter and full measures of turn in everyday situations (AC9M2M05) (Year 2 Measurement)
- identify angles as measures of turn and compare angles with right angles in everyday situations (AC9M3M05) (Year 3 Measurement)
- estimate and compare angles using angle names including acute, obtuse, straight angle, reflex and revolution, and recognise their relationship to a right angle (AC9M4M04) (Year 4 Measurement)

Cross-curriculum priority

This activity connects to the following **Sustainability** cross-curriculum organising idea:

- **Systems**: Sustainable patterns of living require the responsible use of resources, maintenance of clean air, water and soils, and preservation or restoration of healthy environments. (SS2)

Teacher professional learning opportunities

We would like to thank the Australian Government Department of Education for funding our Lending Library and the associated resource development.

We run a range of STEM programs for Australian teachers, including our online CSER MOOC courses, free professional learning events, and our National Lending Library.

Our free, self-paced online courses available from CSER and Maths in Schools in the following areas:

- Decoding Digital Technologies - Primary
- Digital Technologies + X - including a Sustainability module *
- Cyber Security and Awareness – Primary and Secondary
- Teaching AI in the classroom – Primary and Secondary
- Maths in Schools – Foundation – Year 2, Year 3 to 6 and Year 7 to 10

www.csermoocs.adelaide.edu.au

Organics

Fruit and vegetable scraps, tea bags, coffee grounds, and small amounts of paper towels.

E-waste

Old phones, batteries, broken laptops, keyboards, power cords, and small printers.

Paper and cardboard

Office paper, newspapers, magazines, cardboard boxes (flattened), and manila folders.

Plastic containers

Water bottles, soft drink and juice bottles, yogurt containers and milk bottles.

Soft Plastics

Bread bags, cereal box liners, frozen vegetable bags, plastic shopping bags, and lolly wrappers.

Reusable

Old good clothing, crockery, clean containers

Might be re-used or go to an Op Shop

Landfill

Items that cannot be recycled - dirty or made of mixed materials

Aluminium and Steel

Soft drink cans, food tins (e.g., tuna, beans), and empty aerosol cans (must be empty).

Organic materials that will breakdown and be re-used.
Food scraps.

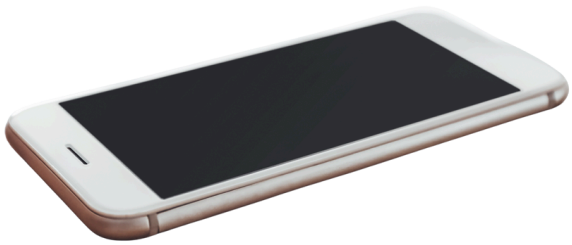
Banana skin

Apple core

Empty containers

Clean used clothing

Old mobile phone



Old batteries

Newspaper

Paper

Plastic bag

Bubble wrap

Plastic bottles

Milk container

Tin can

Aluminium can

Used coffee cup

Lolly wrapper

Used take away