Investigate and Innovate with CSIRO

CSIRO Robot Responders

Space

My name:	
My team:	
Our focus question:	

Student workbook and resources

Acknowledgement of Country

CSIRO acknowledges the Traditional Owners of the lands, seas and waters of the area that we live and work on across Australia. We acknowledge all Aboriginal and Torres Strait Islander peoples and their continuing connection to their culture and pay our respects to Elders past and present. CSIRO is committed to reconciliation and recognises that Aboriginal and Torres Strait Islander peoples have made contributions to all aspects of Australian life including culture, economy and science.

'Eternal Wisdom,
Infinite Innovation'
artwork by Rachael Sarra, working with Gilimbaa.

Contents

Student reference sheet

The Australian Academy of Science Launch, Inquire, Act (LIA) framework helps us structure scientific investigations so that students:

- **Launch** by exploring and connecting to real-world phenomena,
- **Inquire** by investigating and analysing questions, and
- **Act** by applying, communicating and reflecting on our findings.

It's a way to learn science like real scientists do!

PHASE 1: LAUNCH	**Purpose:** get curious, connect to the world, and ask a great question. **What you'll do:** Explore a phenomenon or scenario. Think about your own experience and ask: "What's going on here?". Identify what you already know and what you wonder about. Discuss why the topic matters. **Key questions:** • What do I see or experience? • What might be happening? • Why is this important?	Launch
PHASE 2: INQUIRE	**Purpose:** design and carry out an investigation to answer your question. **What you'll do:** Formulate a testable question. Plan your investigation: decide variables, controls, method. Collect data (measure, record, repeat). Graph and analyse results to spot trends or patterns. **Key questions:** • What variables will I change, and what will I measure? • How will I make it fair? • What do my results show?	Inquire
PHASE 3: ACT	**Purpose**: use your findings to communicate, reflect, and apply to the real world. **What you'll do:** Draw conclusions based on your evidence. Reflect on your method: what worked, what could you improve? Apply your understanding: how does your investigation link to real-life scientific research or technology? Share your findings through a poster, presentation, or video. **Key questions:** • What did I learn and why does it matter? • How could I do better next time? • How can this knowledge be used in the real world?	Act

Teaching and learning icons:

The icons identify the way you will learn for each activity and provide guidance on how you will engage with the activities.

About robots and space environments

What do you know about robots and space environments? Write or draw the first thing that comes to mind to complete the sentence starter for each box below.

This topic is about…	My initial thoughts…
•	•

What I already know about this topic…
•

What is a robot?

Write a response and draw a picture in boxes below.

What is a robot?	Draw a robot:
What makes an environment dangerous for humans?	Draw a dangerous environment for humans:

What features help a robot move through challenging terrain?	Draw features of a robot to help it move through challenging terrain:

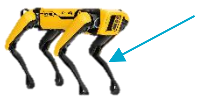
Why might robots be used instead of humans in some environments?

What do you know about robots?

Have you ever encountered a robot at home, school, or a public place? What did it look like? What components did it have. What was its purpose?

List as many robot components as you can think of. •

Draw a line from the robot to the component name, then write a short definition of the component:

		Motor:
		Legs:
		Arm:
		Computer:
		Tracks:
		Camera:

Features of the moon

Using the image and research from articles on the internet, label the geological features of the moon.

Dry, dusty, rocky surface: The Moon is covered by a layer of fine dust and broken rock called regolith.

Word bank:

- Crater
- Valley
- Lava tube
- Highlands
- Luna maria
- Impact site
- Rilles
- Shadow
- Sunlit.

Orbital stations

Compare and contrast the International Space Station and the Tiangong Space Station:

How are they alike?

How are they different?	
International Space Station	Tiangong Space Station

What kinds of experiments would be useful to conduct in space?

Discussion

Can you summarise the challenge or problem?

Why is a solution needed?

Who will be impacted by the problem and the solution?

Investigation – CSIRO Robot Responders

Space environments are some of the most extreme and challenging places humans can explore. They are vast, airless and exposed to extreme temperatures, radiation and microgravity, making them dangerous and difficult for humans to access. These environments may include the surface of planets and moons, as well as space itself, where there is no oxygen and very little protection from harmful radiation. Surfaces can be rocky, dusty and uneven, with craters, steep slopes and unknown hazards. In many cases, sending humans into these environments is highly risky or not possible at all.

Despite these challenges, exploring space is important. Scientists study space to learn more about planets, search for signs of life and understand how our solar system formed. Engineers and scientists at organisations like CSIRO and space agencies design robots to explore these environments safely. These robots must be carefully designed to move across unfamiliar terrain, collect data, withstand harsh conditions and operate without direct human control.

Designing a robot for aspace exploration requires engineers to think carefully about movement, stability, protection, sensors and materials. Engineers test and improve their designs to make sure the robot can function in difficult conditions.

CSIRO engineering design process:

1. Identify the problem – What's going wrong? Who needs help? Where will the robot be used?
2. Research and learn – How other robots do similar jobs? What environment will the robot work in?
3. Imagine possible solutions – What shape will it be? Should it have wheels, legs or tracks?
4. Plan the best idea – Which idea solves the problem? Is it safe?
5. Build a prototype – What do I need to build? 3D printed parts? Household materials? Lego?
6. Test and improve – Does it do the job? Is it breaking? What do I need to fix on the robot for it to work?
7. Share and reflect - What worked? What didn't work? What we'd improve next time?

Aim:

To design, build and test a robot that can successfully explore a space environment where humans cannot easily go. You will investigate how different design features, materials and movement systems help a robot operate in extreme conditions such as low gravity, vacuum, radiation and uneven terrain. Through testing and evaluation, you will use evidence to improve your robot design so it can move safely, avoid hazards and operate effectively in a simulated space environment.

Focus question:

How can we design a robot that can successfully explore a space environment that is too dangerous or difficult for humans to access?

Prediction:

Predict how effective your robot design will be at successfully exploring a space environment.

CSIRO Robot Responders game: design your robot prototype

In this activity, you will design a robot prototype model that can successfully explore space environments that are too dangerous or difficult for humans to access. Your prototype is not required to work like a real robot. Instead, it should clearly show:

- The robot's shape and structure
- Its internal components (parts inside the robot)
- Its external components (parts you can see)
- Not exceed the budget allowance.

You will use this model to explain how your robot could successfully explore a space environment in the Robot Responders game.

Identify the problem:

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Describe the environment your robot will be working in?

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Explain what functions your robot can perform:

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Make a sketch of your robot and label the features below:

Robot name:

Budget sheets

Refer to cost card for component pricing.

While all available components are listed, you do not need to use every component in your design. Select only the components that best help your robot achieve the mission objectives.

Attempt 1 – Budget: 100 credits

Component:	Selection	Credits
Base		
Locomotion		
Motor		
Head		
Left arm		
Right arm		
Batteries		
LiDAR		
Total:		

Working out:

Attempt 2 - Budget: 100 credits

Component:	Selection	Credits
Base		
Locomotion		
Motor		
Head		
Left arm		
Right arm		
Batteries		
LiDAR		
Total		

Working out:

Attempt 3 - Budget: 100 credits

Component:	Selection	Credits
Base		
Locomotion		
Motor		
Head		
Left arm		
Right arm		
Batteries		
LiDAR		
Total:		

Working out:

Attempt 4 - Budget: 100 credits

Component:	Selection	Credits
Base		
Locomotion		
Motor		
Head		
Left arm		
Right arm		
Batteries		
LiDAR		
Total:		

Working out:

CSIRO Robot Responders game instructions

Option 1: Plugged

Access https://www.csiro.au/en/education/Resource-Library/Robot-Responders-HTML-game and build your prototype in the game

Access the CSDIRO Robot Responders game
Open the CSIRO *Robot Responders* online game on your device using the link provided by your adult. Use your design plan to select robot components and build your digital robot.

Test your robot
Launch your robot into the mission environment and observe how it performs. Pay attention to how well it navigates obstacles, completes tasks and manages the challenges presented.

Review, refine and retry
Failure is an important part of the engineering design process. If your robot does not successfully complete the mission:

- review your robot design
- identify which features were successful and which were not
- modify your design and component choices
- test your robot again.

Continue improving and testing your robot until it successfully completes the mission or performs more effectively.

Option 2: Unplugged

Print and cut cards on pages 20-21.

How to complete the unplugged Robot Responders mission:

1. **Read the mission brief**

   Carefully read the scenario and identify the problem the robot needs to solve. Consider the environmental challenges, mission goals and design requirements.

2. **Follow the CSIRO engineering design process**

   Use the engineering design process to:

   - define the problem
   - research and learn
   - brainstorm possible solutions
   - plan and sketch your robot design
   - create a prototype
   - test and improve your design
   - share and reflect.

3. **Develop a budget**

   Your total budget is 100 credits. Review the available robot components and their costs using the cost card. Select features that will help your robot complete the mission while staying within your allocated budget.

4. **Design your robot**

   Create a labelled blueprint showing the key features, components and functions of your robot. Explain how each feature will help solve the mission.

5.

Construct a prototype	Play Robot Responders card game
Build a physical prototype using everyday materials such as cardboard, paper, recycled materials, craft supplies or classroom construction materials.	Go to https://www.csiro.au/en/education/Resource-Library/Investigate-and-Innovate-with-CSIRO/Robot-Responders Players work together or compete to design a robot that can complete an important mission. Each turn, you collect and swap cards to build your robot, making sure it includes all the essential components. The winner is the first player or team to complete the robot and successfully meet the mission requirements while staying within budget.

6. **Test and refine your design**

   Evaluate how effectively your prototype meets the mission requirements. Make improvements based on any challenges or limitations you identify.

7. **Present your solution**
   Present your robot design to the class, explaining:
   - The problem your robot solves
   - Key design features
   - How you managed your budget
   - Any improvements you made during the design process.
8. ***Optional*: Teacher assessment**

   Your teacher may assess your robot design, prototype, application of the engineering design process, and your ability to justify how your solution meets the mission requirements.

Robot Responders mission card: Space

Mission card #1: Lunar sample collection

Scientists have identified several locations on the Moon that may contain valuable geological samples. By studying rocks and soil from these locations, researchers hope to learn more about the Moon's history, how planets form and whether resources can support future human exploration.

The collection zone is located near a rugged canyon system containing steep slopes, rocky outcrops and deep shadowed areas. Engineers need a specialised robotic rover capable of travelling safely through the environment while collecting and transporting samples back to a central base station.

The mission presents several challenges:

- Some collection sites are difficult to reach
- Rocky terrain can damage equipment
- The robot has limited energy available
- Lunar dust can interfere with moving parts
- Samples must be handled carefully to avoid contamination

Your engineering team has been selected to design a robotic sample collection rover for the mission.

Your budget: 100 credits

At the end of the mission, your team will present how your robot design could help scientists collect and transport valuable lunar samples while overcoming the challenges of the environment.

Your task

Mission #1: Lunar sample collection

Your robot must be able to:

- Navigate around obstacles & steep slopes
- Locate & collect rock or soil samples
- Safely transport samples
- Travel across challenging terrain
- Operate in dusty conditions
- Return collected samples to the base station

Engineers have limited materials, power and budget available for the mission. Your team must decide which robot features are most important.

As you design your robot, think about:

- How will your robot collect and store samples?
- What type of robotic arm or gripper will it need?
- How will it travel safely across rough terrain?
- How can the robot conserve energy throughout the mission?
- What design features will help protect the samples?
-

Using the engineering design process, your team will:

- Define the problem.
- Optional: Research and learn.
- Brainstorm possible solutions.
- Sketch and label your robot design.
- Build a physical prototype using everyday materials.
- Test and improve your design based on feedback and failures.
- Share and reflect.

Robot Responders mission card: Space

Mission card #2: Lunar recovery mission

A scientific exploration rover has been conducting geological surveys deep within a remote lunar canyon system. During its mission, the rover became trapped after a systems failure caused it to lose mobility. Scientists can still communicate with the rover, but it cannot move or activate its recovery beacon without assistance.

The stranded rover is carrying valuable scientific data collected from the canyon. If the recovery beacon is not activated, the mission could be lost, and future exploration plans may be delayed.

The mission route is the most challenging environment explored so far. The canyon contains:

- Steep and unstable slopes
- Large boulder fields
- Fragile rock walls that may collapse
- Lava vents and hazardous terrain
- Narrow passages
- Areas that are difficult to navigate and communicate through

Your engineering team has been selected to design a robotic sample collection rover for the mission.

Your budget: 100 credits

At the end of the mission, your team will present how their robot design could successfully rescue the stranded rover and recover valuable scientific data.

Your task

Mission #2: Lunar sample collection

Your robot must be able to:

- Travel through the canyon system
- Safely navigate dangerous terrain
- Avoid environmental hazards
- Reach the stranded rover
- Activate the recovery beacon
- Return mission data to the lander

Engineers have limited materials, power and budget available for the mission. Your team must decide which robot features are most important.

As you design your robot, think about:

- How will your robot collect and store samples?
- What type of robotic arm or gripper will it need?
- How will it travel safely across rough terrain?
- How can the robot conserve energy throughout the mission?
- What design features will help protect the samples?

Using the engineering design process, your team will:

- Define the problem.
- Optional: Research and learn.
- Brainstorm possible solutions.
- Sketch and label your robot design.
- Build a physical prototype using everyday materials.
- Test and improve your design based on feedback and failures.
- Share and reflect.

Robot Responders cost card: Space

Budget: 100 credits

Body (base)	Compact core 10 credits	Standard frame 15 credits	Heavy platform 20 credits	Basic thermal insulation 25 credits	Active cooling and heating insulation 30 credits
Wheel (locomotion)	Standard wheels 10 credits	Rubber tracks 15 credits	Single thruster 20 credits		
Arm (manipulation)	Basic gripper 10 credits	Drill 15 credits	Arm 20 credits	Precision arm 25 credits	Laser arm 30 credits
Motor	Brushed motor 10 credits		Brushless motor 20 credits		High torque motor 30 credits
Head (camera)	Single grayscale 10 credits	HD colour 15 credits	Humanoid 20 credits	Stereo vision 25 credits	Thermal camera 30 credits
Battery	Small capacity 10 credits	Solar array 15 credits	Solar panel 20 credits	Medium capacity 25 credits	Large capacity 30 credits
LiDAR/ SLAM		2D LiDAR/SLAM 15 credits		3D LiDAR/SLAM 25 credits	

Reflection

Describe the design features that helped your robot successfully complete the mission. •
Which robot components (movement, sensors, computing, etc.) were most important for exploring the space environment successfully? •
What challenges did your robot face during the mission, and how did you improve your design? •

Shark tank pitch plan

You are an innovator presenting your idea to a panel of investors! Your task is to showcase your robot design and pitch it in a creative format (e.g. video, speech, poster, slideshow, or other).

Your idea should solve a real problem or improve something using science. Use this planner to organise your thinking before creating your final pitch.

Your goal is to convince your class that **your robot is the most successful at navigating a space environment.**

1. What is your idea? Give your robot a name and describe how it functions in one or two sentences.

2. What problem is your robot solving? What issue, need or challenge does your robot address?

3. Who will benefit from your robot and how will it make a difference?

4. How does it work? Draw and label your robot and its components:

5. Explain how scientific knowledge supports your design:

6. How did you stick to a budget? Did you go over or under budget?

7. Describe your performance in the game. How many times did you have to modify your design? What modifications were the most successful?

Investment pitch

8. Opening hook: How will you grab your audience’s attention in the first 10 seconds**?**
    - Question
    - Surprising fact
    - Mini story
    - Demonstration.

Write your opening:

____

____

____

9. Key points to include (make sure your pitch answers these):
    - What is it?
    - Who is it for?
    - Why is it better/different?
    - Why should the audience invest/support it?
    - What evidence supports your idea?
    - Why is it better than other robots?
    - What are its limitations or risks?

10. The ask – What do you want from your audience? (Support, funding, attention, or action)?

____

____

____

11. How will you present it?

- Video
- Poster
- Speech
- Slideshow
- Other: ________________

Materials/tools needed:

____

____

Final check list -

- Clearly explain your idea
- Show how it solves a problem
- Use scientific knowledge
- Speak confidently/present clearly
- Engage your audience

Shark tank pitch review – *Choose one peer shark tank pitch to review*:

Robot name:	
Robot description	
Who is it for?	
Pitch strong points:	
Pitch weaknesses:	
What would you improve about their pitch?	

Presentation plan

How will your team present the project? What is the best way to share everything you have learned?

Use this table to plan your presentation, including who is responsible for each task/section.

Task	Team member/s responsible	Due date
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•

Presentation notes

Use this space to plan your presentation. You might like to draw what your set-up will look like or write a script and some dot points to talk about.

Glossary

Word	Definition
Actuator	A component that causes movement, such as a robotic arm, wheel, track or gripper.
Autonomous	Able to operate independently without direct human control.
Battery	A device that stores energy and powers the robot.
Boulder field	An area covered with large rocks that can make movement difficult for robots.
Camera	A sensor used to capture images and collect visual information about the environment.
Canyon system	A deep valley or network of valleys that can create navigation challenges for robots.
Component	A part of a larger system that performs a specific function.
Control system	The part of a robot that processes information and directs actions.
Crater	A bowl-shaped depression formed when an object impacts the surface of a planet or moon.
Geological sample	A rock, soil or dust sample collected for scientific investigation.
Gripper	A robotic attachment used to pick up, hold or move objects.
Hazard	A feature or condition that could damage a robot or make a mission more difficult.
Lava tube	An underground tunnel formed by ancient flowing lava.

Lidar	Light Detection and Ranging (LiDAR); a sensor that uses lasers to measure distances and map surroundings.
Locomotion	The method a robot uses to move, such as wheels, tracks or legs.
Lunar environment	The conditions found on the Moon, including rough terrain, dust, low gravity and extreme temperatures.
Mapping	The process of creating a representation of an environment to identify hazards, routes and areas of interest.
Mission	A specific task or objective that a robot is designed to complete.
Navigation	The process of planning and following a route through an environment.
Obstacle	Something that blocks movement or makes a task more difficult, such as rocks, slopes or craters.
Planetary exploration	The use of robots and scientific instruments to investigate planets, moons and other objects in space.
Power source	The component that supplies energy to the robot, such as a battery or solar panel.
Prototype	An early model used to test and improve a design.
Recovery beacon	A device that sends a signal to help locate and recover a stranded robot or vehicle.
Remote operation	Controlling a robot from a distant location, such as Earth.
Robot	A machine that can sense, process information and perform actions.
Rover	A robot designed to travel across the surface of a planet, moon or other terrain.
Sample collector	A robotic tool used to collect and store rocks, soil or other materials.

As Australia's national science agency, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Creating a better future for everyone.

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