Investigate and Innovate with CSIRO

Robot Responders

Caves and lava tubes

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 Torress 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' **a**rtwork 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, caves and lava tubes:

What do you know about robots, caves and lava tubes? 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.

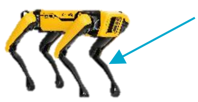
What is a robot?	Draw a robot:
What makes an environment dangerous for humans?	Draw a dangerous environment for humans:
What features help a robot move through rough terrain?	Draw features of a robot to help it move through rough terrain:
Why might robots be used instead of humans in some environments?	

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:

How can robots help humans in caves and lava tubes?

Why might caves and lava tubes be hazardous and/or dangerous for humans? List the different dangerous features that may be present in caves and lava tubes:

Caves	Lava tubes
•	•

Discussion

Can you summarise the challenge or problem?

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Why is a solution needed?

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Who will be impacted by the problem and the solution?

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Investigation – Robot Responders

Caves and lava tubes are some of the most challenging and mysterious environments on Earth. They are often dark, narrow, uneven and unstable, making them difficult and dangerous for humans to explore. These environments can contain sharp rocks, steep drops, loose surfaces, water and very low light levels. Lava tubes, which are tunnels formed by flowing lava during volcanic eruptions, can also have fragile ceilings, rough floors and sudden collapses. Some caves and lava tubes are so hazardous that sending people inside could result in serious injury.

Despite these challenges, exploring caves and lava tubes is important. Scientists study caves to learn about geology, water systems, ancient environments and unique living organisms. Engineers and scientists at organisations like CSIRO use robots to explore places that are unsafe or impossible for humans to reach. These robots must be carefully designed to move over rough surfaces, avoid obstacles, collect information and operate safely without putting people at risk.

Designing a robot for a cave and/or lava tube environment 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. *Optional:* 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 cave environment where humans cannot. You will investigate how different design features, materials and movement systems help a robot navigate dark, uneven and confined spaces. Through testing and evaluation, you will use evidence to improve your robot design so it can travel safely, avoid hazards and operate effectively in a simulated cave environment.

Focus question:

How can we design a robot that can successfully explore cave and lava tube environments that are too dangerous or difficult for humans to access?

Prediction:

Predict how effective your robot design will be at successfully exploring a cave or lava tube environment.

Robot Responders game: design your robot prototype

In this activity, you will design a robot prototype model that can successfully explore cave and lava tube 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 cave or lava tube 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:

Robot Responders game instructions

Option 1: Plugged

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

Access the Robot Responders Game
Open the *Robot Responders* HTML 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 18-20.

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. **Approval process**

   Students should seek teacher approval before constructing their robot prototype to ensure their design is safe, suitable and meets the mission requirements.

6.

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/Resource-Library/Robot-Responders-HTML-game**. 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.

7. **Test and refine your design**

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

8. **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.

9. ***Optional*: Teacher assessment**

   Your teacher will 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 Caves and lava tubes

Mission card #1: The cave mapping

A team of scientists have discovered a large underground lava tube system beneath an ancient volcanic region. The caves may contain important geological information about past volcanic eruptions, underground water movement and rare cave ecosystems. However, the tunnels are too dangerous for humans to fully explore.

The cave environment contains:

- Unstable rocks
- Steep & uneven terrain
- Narrow passages
- Complete darkness
- Deep drop-offs
- Thick dust blocking visibility & signals

Your engineering team has been asked to design a robotic explorer that can successfully travel through the cave and help create a map of the underground system.

Your budget: 100 credits

Your task

Mission card #1: The cave mapping

Your robot must be able to:

- Move across rough terrain
- Navigate in darkness
- Avoid obstacles and drop-offs
- Collect & return information
- Survive dust & rocky conditions

Your team must also work within a limited budget and carefully decide which robot features are most important for the mission.

As you design your robot, think about:

- What movement system would work best?
- How will the robot "see" in the dark?
- How will it avoid obstacles?
- How can the robot communicate underground?
- What features will help it stay stable on uneven surfaces?

Using the engineering design process, your team will:

- Define the problem
- 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.

At the end of the challenge, your team will present how your robot design could help scientists successfully explore dangerous cave systems.

Robot Responders: Caves and lava tubes

Mission card #2: The deep cave search

A group of cave researchers entered a remote lava tube system to investigate unusual rock formations deep underground. During the expedition, part of the cave became blocked by fallen rocks, preventing the team from continuing safely.

The cave system is extremely dangerous because:

- Large piles of rubble block pathways
- Some tunnels are too small for humans to enter
- The ground is uneven & slippery
- Visibility is almost zero
- Communication with the surface is unreliable

Scientists and rescue teams have decided it is safer to send robots into the cave instead of humans.

Robots can explore areas that are considered too dirty, dangerous or difficult for people to access.

Your budget: 100 credits

Your task

Mission card #2: The deep cave search

Your engineering team must design a robot that can:

- Explore tight underground tunnels
- Move safely over rocks & rubble
- Search for safe pathways
- Carry equipment or emergency supplies
- Communicate information back to the recue team

Your team must also work within a limited budget and carefully decide which robot features are most important for the mission.

Your team must carefully decide:

- Which robot features are most important
- How your robot will move through the cave
- How it will stay balanced
- How it will overcome obstacles
- How it will send information to the surface team.

Using the engineering design process, your team will:

- Define the problem
- 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.

At the end of the mission, your team will explain how your robot design helps solve the challenges of exploring dangerous lava tube environments.

Robot Responders cost card – Caves and Lava tubes

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 cave 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 caves and/or lava tubes.**

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

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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?

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____

____

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:

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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)?

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11. How will you present it?

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

Materials/tools needed:

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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

Term	Definition
Actuator	A component that causes movement, such as a robotic arm, wheel or gripper.
Autonomous	Able to operate independently without direct human control.
Battery	A device that stores energy and powers the robot.
Component	A part of a larger system that performs a specific function.
Constraints	Limitations or restrictions that affect a design, such as cost, size or available materials.
Control System	The part of a robot that processes information and directs actions.
Exploration Robot	A robot designed to investigate areas that are difficult, dangerous or inaccessible to humans.
Gripper	A robotic attachment used to pick up, hold or move objects.
LiDAR	Light Detection and Ranging (LiDAR): A sensor that uses laser light to measure how far away objects are.
Locomotion	The method a robot uses to move, such as wheels, tracks, legs or whegs (Wheel + legs)
Mission	A specific task or objective that a robot is designed to complete.
Obstacle	Something that blocks movement or makes a task more difficult.

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.
Rescue Robot	A robot designed to assist in search, rescue or emergency situations.
Robot	A machine that can sense, process information and perform actions.
Sensor	A device that detects information about the environment, such as light, temperature, distance or movement.
SLAM	Simultaneous Localisation and Mapping (SLAM): A component for robots to create a map of their surroundings while determining its location.
System	A group of connected components that work together to perform a function.
Terrain	The physical features of an area, such as rocky, sandy, steep or uneven ground.
Trade-off	A compromise where improving one feature may require sacrificing another.
Whegs	Wheel-leg hybrids that combine features of wheels and legs to help robots move across rough terrain.

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

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