Investigate and Innovate with CSIRO

CSIRO Robot Responders

Marine environments

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 marine environments

What do you know about robots and marine 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:

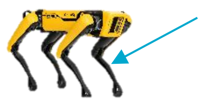
Why might robots be used instead of humans in some environments?

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:

Types of marine environments

Using the image on the board and research from articles on the internet, observe and describe the different types of marine environments and why they may be dangerous to humans to explore:

Marine environment	Organisms that may live there	Danger to humans
• Mainland beaches and coastlines	•	•
• Coral reefs	•	•
• Lagoon floors	•	•
• Water column	•	•
• Continental shelf	•	•

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

Marine environments are some of the most challenging and least explored places on Earth. They can be deep, dark, cold and under extreme pressure, making them difficult and dangerous for humans to access. These environments may include strong currents, rough seafloors, sharp rocks, and areas with very little light or visibility. Some locations, such as deep oceans or under ice, are so hazardous that sending people there could result in serious injury or is simply not possible.

Despite these challenges, exploring marine environments is important. Scientists study the ocean to learn about ecosystems, discover new species, monitor environmental changes and understand how Earth systems work. Engineers and scientists at organisations like CSIRO use robots to explore underwater environments safely. These robots must be carefully designed to move through water, withstand pressure, collect data and operate reliably in conditions where humans cannot survive.

Designing a robot for a marine 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. 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 marine environment where humans cannot. You will investigate how different design features, materials and movement systems help a robot navigate dark, high-pressure, uneven and confined underwater 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 deep-sea environment.

Focus question:

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

Prediction:

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

CSIRO Robot Responders game: design your robot prototype

In this activity, you will design a robot prototype model that can successfully explore marine 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 marine environment in the Robot Responders game.

Identify the problem:

___

___

___

Describe the environment your robot will be working in?

___

___

___

Explain what functions your robot can perform:

___

___

___

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 CSIRO 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 19-20.

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.

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: Marine

Mission card #1: Crown-of-thorns starfish (CoTS) reef rescue

Marine scientists working on the CSIRO Great Barrier Reef monitoring program have discovered a large outbreak of crown-of-thorns starfish (CoTS) damaging sections of coral reef. Crown-of-thorns starfish are native marine animals covered in long toxic spines that feed on living coral. When too many starfish gather in one area, they can rapidly destroy large sections of reef habitat.

The reef environment is difficult and dangerous for divers to manage alone because:

- The starfish have toxic spines.
- Underwater visibility can be poor.
- Large areas of reef need to be monitored quickly.
- Some reefs are deep or difficult to access.
- Repeated surveys are needed to track outbreaks.

Scientists are now investigating how robotic technologies can help monitor reef health, detect crown-of-thorns starfish outbreaks and assist with reef protection efforts. Some robotic systems can use cameras, sensors and artificial intelligence to identify starfish underwater.

Your budget: 100 credits

At the end of the challenge, your team will present how your robot design could help scientists safely explore dangerous marine environments.

Your task

Mission #1: Crown-of-thorns starfish reef rescue

Your robot must be able to:

- Detect or locate Crown-of-Thorns starfish
- Help scientists monitor reef health
- Operate in low-visibility conditions
- Navigate around coral without causing
- Travel safely underwater
- Collect reef data or images

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 move underwater?
- What sensors or cameras might it need?
- How will it avoid damaging coral?
- How can it detect crown-of-thorns starfish?
- How will information be sent back to scientists?

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.

Mission card #2: Coral recruitment and reef restoration

Marine scientists are working to restore damaged coral reef ecosystems after coral bleaching events, storms and crown-of-thorns starfish outbreaks have reduced large areas of healthy coral. Coral reefs are important habitats that support thousands of marine species and help protect coastlines from erosion and strong waves.

One of the biggest challenges facing scientists is helping baby corals survive long enough to grow and rebuild damaged reefs. Baby corals are extremely small and fragile, making them difficult to move, monitor and plant safely by hand. Researchers from CSIRO have developed a soft robotic "hand" that can gently handle and transfer baby corals during reef restoration projects.
Your engineering team has been asked to design an underwater robot that can assist scientists with coral recruitment and reef restoration.

The reef environment presents several challenges:

- Baby corals are fragile and easily damaged.
- Moving baby coral by hand is difficult.
- Survival rates need to be improved.
- Reef restoration requires careful handling.
- Soft robotic technology helps protect baby corals.

Your engineering team has been asked to design an underwater robot that can assist scientists with coral recruitment and reef restoration.

Your budge: 100 credits

At the end of the mission, your team will present how your robot design could help scientists restore and protect coral reef ecosystems for the future.

Mission #2: Coral recruitment and reef restoration

Your engineering team must design a robot that can:

- Safely transport delicate baby corals.
- Operate underwater without damaging coral reefs.
- Identify suitable locations for coral growth.
- Navigate around rocks and coral structures.
- Collect reef data or images.
- Support reef restoration efforts in challenging ocean conditions.

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

Your team must carefully decide:

- How will your robot move underwater?
- How can it gently carry or place baby corals?
- What features will help avoid damaging the reef?
- How will your robot identify safe coral planting areas?
- What tools or sensors might scientists need?

Using the engineering design process, your team will:120

- 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.

Robot Responders cost card: Marine

Budget: 100 credits

Body (base)	Compact core 10 credits	Standard frame 15 credits	Heavy platform 20 credits	Pressure housing 25 credits	
Wheel (locomotion)	Standard wheels 10 credits	Rubber tracks 15 credits	Single thruster 20 credits	Omni-thruster 25 credits	Multi-thruster 30 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 marine 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 marine 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

Term	Definition
Actuator	A component that causes movement, such as a robotic arm, wheel, thruster 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.
Coral Reef	An underwater ecosystem built by corals that provides habitat for many marine organisms.
Current	The continuous movement of water in a particular direction. Ocean currents can affect how robots travel and operate underwater.
Depth	The distance below the water's surface. Increasing depth can affect pressure, light and robot performance.
Environment	The surrounding conditions in which a robot operates.
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 thrusters.

Marine Environment	An area of saltwater such as an ocean, sea, coral reef or estuary where living organisms interact with their surroundings.
Mission	A specific task or objective that a robot is designed to complete.
Obstacle	Something that blocks movement or makes a task more difficult, such as rocks, coral formations or strong currents.
Power Source	The component that supplies energy to the robot, such as a battery or solar panel.
Pressure	The force exerted by water. Pressure increases as depth increases and must be considered when designing marine robots.
Prototype	An early model used to test and improve a design.
Robot	A machine that can sense, process information and perform actions.
ROV	Remotely Operated Vehicle – an underwater robot controlled by a human operator.
Sensor	A device that detects information about the environment, such as light, temperature, distance or movement.
SLAM	Simultaneous Localisation and Mapping (SLAM), a process that allows robots to create a map of their surroundings while determining their location.
Thruster	A propulsion device that pushes water to move a robot through a marine environment.
Team	The physical features of an area, such as rocky reefs, sandy seafloors or coral structures.
Trade-off	A compromise where improving one feature may require sacrificing another.
Underwater Drone	A robot designed to operate beneath the surface of the water to collect data, inspect structures or complete tasks.
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.

CSIRO. Creating a better future for everyone.

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