# CSIRO Robot Responders

Space

**Year level:** Years 5-6, 7-8
**Duration:** National Science Week
**Core concepts:** Robotics components and systems, engineering design process.

## Teacher guide

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'**
**a**rtwork by Rachael Sarra, working with Gilimbaa.

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# Getting started

### 1. Choose your delivery pathway (more information on page 6-7):

- **Plugged:** PowerPoint presentation, student workbook and CSIRO Robot Responders online game.
- **Unplugged:** PowerPoint presentation, student workbook, mission cards, physical prototyping activity and/or Robot Responders card game.

### 2. Introduce robotics concepts using the Classroom PowerPoint (PPT):

Optional CSIRO articles, videos and data resources (listed on page 3) can be used to provide additional real-world context and examples of robotics in action. Discussion starters and further information is found in the presenter notes of the Classroom PowerPoint presentation.

### 3. Guide students through the CSIRO Engineering Design Process:

Using the Student Workbook, students investigate the mission, identify challenges, explore robot components and develop design ideas.

### 4. Test and modify your design using your selected pathway:

- In the **plugged pathway**, students design, test and refine robots using the online game.
- In the **unplugged pathway**, students use mission cards to design solutions and may create a physical robot prototype using available materials.
- The Robot Responders card game can be used as an additional or alternative design activity.

### 5. Reflect and share learning:

Conclude by discussing what worked well, what challenges students encountered and how their designs could be improved.

### Flexible implementation:

Resources can be used individually or in combination. Teachers may adapt activities, groupings and timing to suit available technology, classroom needs and learning goals.

### Prior knowledge and skills

- No prior robotics experience is required.
- The PowerPoint presentation introduces key robotics concepts and can be used to build participant understanding before commencing activities.
- Activities provide opportunities to develop problem-solving, collaboration and communication skills.

## Key learning goals:

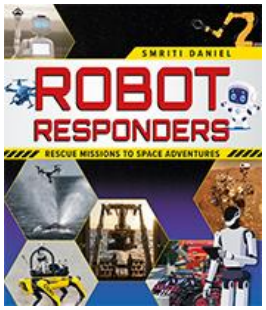
Slide 3 in Robot Responders Classroom PowerPoint Presentation.

## CSIRO research:

### Space:

- CSIRO website: multi-resolution scanning
- CSIRO Research: multi-resolution scanner
- CSIRO and ISS National Laboratory: Testing novel 3D mapping technology to transform space exploration and benefit industries on Earth
- CSIRO News article: CSIRO 3D mapping tech blasts off for International Space Station

## Robot Responders by Smriti Daniel




For further exploration of robotics concepts and real-world robot applications, educators may wish to obtain a copy of Robot Responders by Smriti Daniel, available through CSIRO Publishing.

## Associated documents: Investigate and Innovate with CSIRO webpage

- Investigate and Innovate with CSIRO webpage
- Robot Responders - Student Workbook
- Robot Responders - Classroom PowerPoint Presentation (PPT)
- Australian Curriculum links.

## Icons:

Throughout the investigation you will see these icons (below) to highlight the type of activity and guidance recommended.

# What is the LIA Framework?

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!

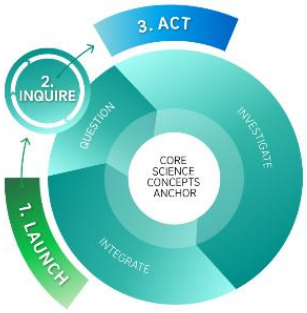



**Figure 1 LIA Framework from the Australian Academy of Science.**

| | | |
|---|---|---|
| PHASE 1: LAUNCH | **Purpose:** get curious, connect to the world, and ask a great question.<br>**What you'll do:**<br>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.<br>**Key questions:**<br>• What do I see or experience?<br>• What might be happening?<br>• Why is this important? | Launch |
| PHASE 2: INQUIRE | **Purpose:** design and carry out an investigation to answer your question.<br>**What you'll do:**<br>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.<br>**Key questions:**<br>• What variables will I change, and what will I measure?<br>• How will I make it reproducible?<br>• What do my results show? | Inquire |
| PHASE 3: ACT | **Purpose**: use your findings to communicate, reflect, and apply to the real world.<br>**What you'll do:**<br>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.<br>**Key questions:**<br>• What did I learn and why does it matter?<br>• How could I do better next time?<br>• How can this knowledge be used in the real world? | Act |


# How to use the Robot Responders resources:

*Flexible implementation:* Teachers may choose to use either the plugged or unplugged pathway, or combine elements of both, depending on available technology, classroom needs and learning goals.

## Teacher guide

Provides educators with background information, preparation requirements, lesson guidance, differentiation opportunities and suggested teaching approaches to support implementation of the Robot Responders resources.

## Classroom PowerPoint

A teacher-led presentation that introduces key concepts, real-world robotics applications, learning activities and discussion prompts. The PowerPoint supports whole-class instruction and guides students through the learning sequence. Teachers can use this resource in the plugged and unplugged delivery of the Robot Responders resources.

The unplugged PowerPoint slides (*slides 31-37*) guides students through the Robot Responders design challenge using space mission cards. It includes budgeting tools, component cost card, prototyping prompts, everyday object substitution ideas, and teacher-only answer cards (*slides 38-39*) and *optional* rubrics (*slides 40-43*) to support assessment and discussion.

## CSIRO Engineering design process

Students are introduced to the CSIRO Engineering design process (*slide 7-8*) which was created in collaboration with real CSIRO roboticists.

## Student workbook

A companion resource that allows students to record observations, respond to questions, develop design ideas, plan investigations, document prototypes and reflect on their learning throughout the resources. Teachers can use this resource in the plugged and unplugged delivery of the CSIRO Robot Responders resources.

| Plugged (internet needed) | Unplugged (no internet required) |
|---|---|
| **Robot Responders online game – www.csiro.au/robotrespondershtmlgame**<br><br>The Robot Responders online game is an interactive digital resource that allows students to design robots for authentic CSIRO-inspired missions in space, marine and cave/lava tube environments. Students select components, test solutions and make design decisions to overcome challenges while exploring key robotics and engineering concepts. | **Robot Responders mission cards – *Pages 21-22 in the student workbook, slides 33-34 in the Classroom PPT.***<br><br>The Robot Responders mission cards provide students with authentic robotics challenges inspired by real-world exploration environments. Each card presents a unique mission scenario and a set of constraints that require students to apply engineering design thinking, problem-solving and creativity to develop a suitable robot solution.<br><br>Students analyse the mission requirements, identify challenges, select appropriate robot features and justify their design decisions before communicating or constructing their proposed solution - a physical prototype using everyday materials. |
| | **Robot Responders card game – www.csiro.au/robotresponders**<br><br>In this interactive card game, students collect robot component cards to build a robot capable of completing a chosen mission. Players must gather essential components, select additional design features and adapt to unexpected action cards that introduce engineering challenges. The game encourages strategic thinking, problem-solving and an understanding of how robot components work together to achieve a mission objective. |

## Recommended exploration of resources:

### Plugged (Internet access)

*PowerPoint presentation, student workbook and Robot Responders online game*

Students explore robotics concepts through a combination of explicit teaching, workbook activities and an interactive digital game. The online game allows students to design and customise robots, test solutions and apply problem-solving skills in realistic space exploration scenarios.

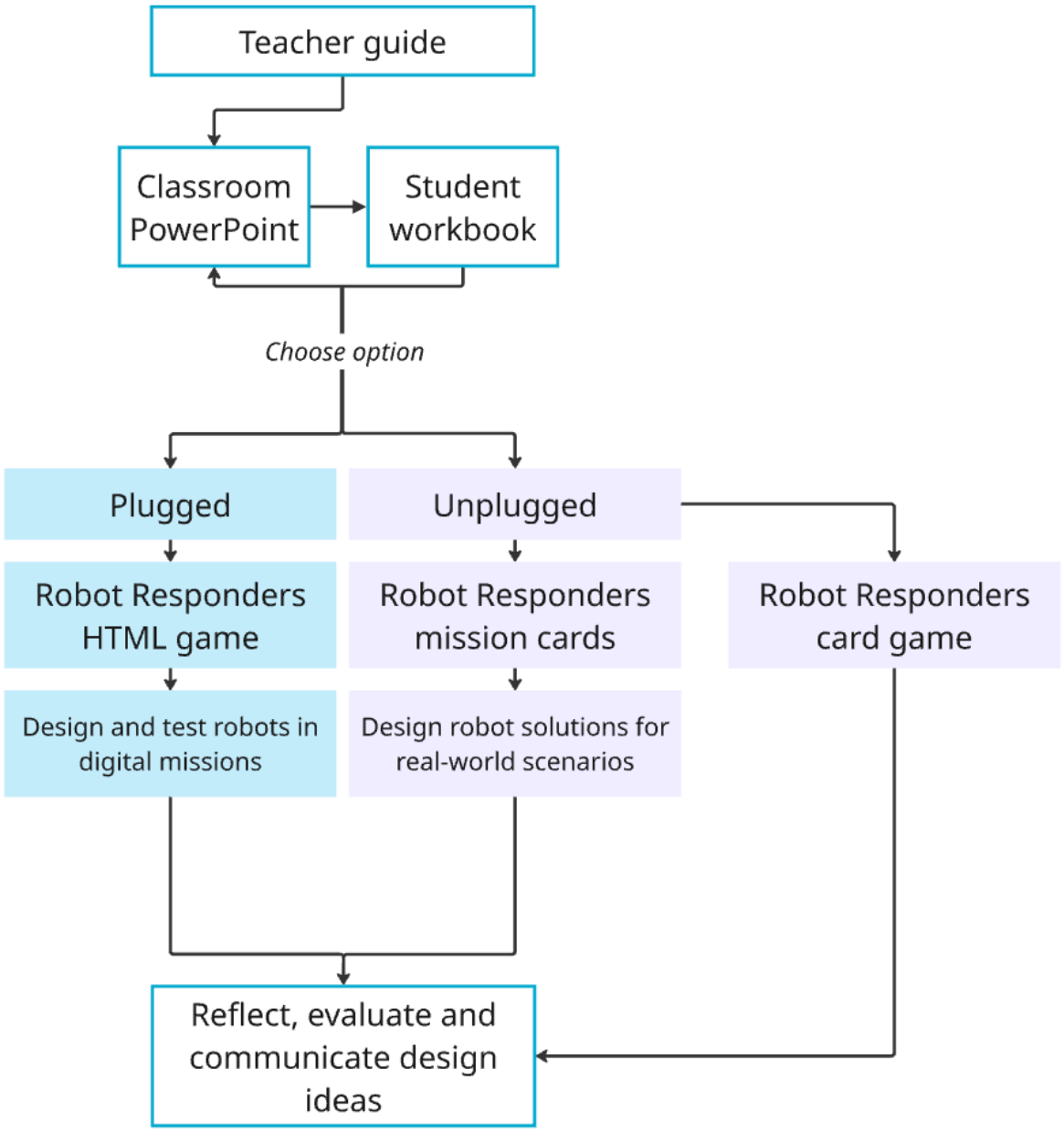
### Unplugged (No internet required)

*PowerPoint presentation, student workbook, Robot Responders mission cards and building physical prototype OR Robot Responders card game.*

Students investigate robotics concepts through teacher-guided activities, design challenges and scenario-based problem solving. Using the mission cards, students design and communicate solutions before creating a physical robot prototype using available classroom materials.

In addition to the mission cards and robot prototyping, students can also test their design skills with the Robot Responders card game to strategically collect and combine robot components while overcoming challenges to design a robot that successfully completes a mission.

## Education resources:



# Classroom PowerPoint (PPT) presentation guide – plugged and unplugged

In the PPT, activities correspond with a specific phase of the Australian Academy of Science Education Launch, Inquire, Act (LIA) Framework to guide teachers and students through a CSIRO Robot Responders investigation. See presenter notes in Classroom PPT for discussion notes and talking points.

| LIA Framework stages | **Slide #** Classroom PowerPoint Presentation (PPT)<br>**Page #** (Student Workbook) | Teacher guidance | Student guidance |
|---|---|---|---|
| | **Slide 2**<br>**Page 2** | Teacher reference slide - LIA Framework and icon explanation | Student reference sheet – Launch, Inquire, Act (LIA) framework and icon explanation |
| | **Slide 3** | Learning Objectives: Years 5-6 and years 7-8. | |
| | **Slide 4** | Choose your own adventure: Plugged or unplugged delivery. | |
| | **Slide 5** | Agenda – Overview of PPT content | |
| Launch | **Slide 6**<br>**Page 3** | *Launch phase* – Lead the initial discussion of space robots by encouraging a whole class discussion, think-pair-share and independent recording of prior knowledge on page 3. | *Launch phase* - Students record initial thoughts/prior knowledge |

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| | | | on page 3 of the student workbook.<br><br>Refer to page 2 to explore 'Launch phase' in more detail, if required. |
| | **Slide 7-8** | Slide 7- CSIRO Engineering process – introduce the CSIRO Engineering process to the students. Refer to presenter notes for talking points and discussion.<br><br>Slide 8- Watch the video about the CSIRO Engineering process. | Participate in discussion and watch the CSIRO engineering design process video. |
| | **Slide 9**<br>**Page 4** | Explore what the class knows about robots, how they operate in our everyday lives and their function through a whole-class discussion.<br>Record initial thoughts on the board.<br>Guide students to complete the activities in the, 'What is a robot?' page in their workbooks. Students are encouraged to write their answers and/or draw pictures.<br><br>Refer to presenter notes for discussion starters, explanations and answers. | Participate in whole-class discussion and complete workbook page 4. |
| | **Slide 10 -11**<br>**Page 6** | Slide 10 - Introduce the different components a robot may have. Explore:<br>1. Base<br>2. Locomotion<br>3. Motor<br>4. Head<br>5. Arms<br>6. Internal components<br>7. Controller | Participate in whole class discussion and complete page 6. |

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| | | Refer to presenter notes for more information and discussion starters.<br><br>Slide 11 – Explore parts of the CSIRO robots and discuss what they have in common. Encourage students to label other components on the board.<br>Refer to presenter notes for more information and discussion starters. | |
| | **Slides 12-14** | Slide 12 - Explore why robots are used to explore dirty, dangerous and dull environments.<br><br>Slide 13 -Introduce space environments to the class and discuss:<br>• What is space?<br>• Where space "begins" Kármán line<br>• What space contains<br>• How CSIRO is helping develop technologies to solve the challenge of living and working beyond earth<br><br>Discussion points and explanations can be found in the presenter notes.<br><br>Slide 14- Watch the video showing 'Astrobee' collecting data in the International Space Station. Refer to presenter notes for future information and discussion notes. | Participate in discussion. |
| | **Slide 15**<br>**Page 7** | Slide 15 – Lunar environments<br><br>Discuss features and prior knowledge about the moon and lunar environments.<br><br>Discuss that The Moon isn't a flat, smooth surface. It contains | Students use the image on slide 15 and their own research to populate and complete page 7 in the student workbook. |

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| | | craters, rocky terrain, steep slopes and permanently shadowed regions. Before humans can safely explore these areas, robots are often sent first to map the terrain, identify hazards and collect information. Engineers must carefully design robots that can survive extreme temperatures, navigate difficult terrain and operate in remote environments.<br><br>As a class, explore different geological features of the moon including rilles, rocky surface, lunar lava tubes, moon highlands, lunar maria, lunar craters and more.<br><br>Discussion points and explanations can be found in the presenter notes.<br><br>Students then use the image on slide 15 and their own research to populate and complete page 7 in the student workbook.<br>Discussion points and explanations can be found in the presenter notes. | |
| | **Slide 16**<br>**Page 8** | Introduce space stations or 'orbital stations' to the class as a different space environment where humans live currently.<br><br>Discuss what is a space station and its purpose.<br><br>Identify features and compare and contrast the International Space Station and the Tiangong Space Station. Students can write their observations on page 8 in their student workbook.<br><br>Pose the question What kinds of experiments would be useful to | Students complete page 8 in their student workbook. |

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| | | conduct in space? And discuss as a class.<br><br>Encourage students to write their response on page 8 in their student workbook. | |
| | **Slide 17** | Lead a class discussion on why space environments are dangerous?<br><br>Discuss basic human needs for survival and how humans would require air, food, water, protection from radiation and suitable living temperatures for survival.<br><br>Using butcher's paper and sticky notes, answer the question: Can robots help humans safely explore the space? With reasons why and how. | Participate in class discussion and in brainstorming activity. |
| | **Slide 18**<br>**Page 9** | As class or think-pair-share, go through the discussion questions to identify key features of the robotics investigation including summarising the challenge or problem, discussing why a solution is needed and who will be impacted by the problem/solution.<br><br>Answers and key points can be found in the presenter notes. | Students complete the questions on page 9. |
| Inquire | **Slide 19**<br>**Page 2** | *Inquire Phase* – Explain the purpose of the inquire phase to design and carry out an investigation to answer the focus question.<br><br>Refer to presenter notes for introduction. | Refer to page 2 to explore the 'Inquire Phase' in more detail, if required. |

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| | **Slides 20-24**<br>**Pages 10-14** | Slide 20- Guide students to complete the investigation – Robot Responders.<br><br>Start with the introduction of the investigation (Slide 20 and page 10-11) and introduce the aim. Refer to the presenter notes for key points.<br><br>Slide 21 – Encourage students to predict the outcome of their robot design. Students can write their predictions on page 11 in their workbook.<br><br>Slides 22– Introduce the task to begin prototyping a robot design.<br><br>Slide 23 – Continue the discussion about prototyping by completing page 12-13 in the student workbook.<br><br>Slide 24 - Students will be required to adhere to a budget of 100 credits and use the cost card to calculate the total cost of their robot. Students can use page 14 to calculate their budget.<br><br>Please note: The 100-credit budget is only used for prototyping and the Unplugged investigation. In the CSIRO Robot Responders game, each mission has its own unique budget. | Students view the introduction, focus question and write a prediction (page 10-11).<br><br>Students begin prototyping their robot design by answering the questions on page 12, sketching their prototype on page 13 and calculating the budget on page 14. |

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| | **Slide 25 –** Plugged and unplugged activities overview<br><br>**Pages 18-20**<br>Detailed Instructions for plugged and unplugged activities.<br><br>**Slides 31-37**<br>Unplugged activities.<br><br>**Pages 21-22**<br>Unplugged mission cards:<br><br>**Page 23**<br>Cost card<br><br>**Robot responders card game linked here: www.csiro.au/robotrespondershtmlgame** | Refer to Robot Responders game instructions on pages 18-20 for plugged and unplugged delivery in the student workbook.<br><br>Teacher to decide whether the activities are conducted in small groups or independently.<br><br>**Plugged:**<br>Allow students to navigate to the CSIRO Robot Responders game webpage and transfer their prototype sketch onto the game.<br>Students are exploring real-world space scenarios conducted by CSIRO scientists.<br><br>Encourage students to take note of any wins or failures. Students can take notes of their learnings to then transfer to their reflection in the next phase of the investigation.<br><br>***Optional:*** If the students' robot designs fail, they can re-calculate their budget using the attempt 2-4 budget sheets in the student workbook.<br><br>**Unplugged:**<br>***Teachers may choose whether all groups receive the same mission card or different mission cards.***<br>Using the mission cards (page 21-22 and cost card page 23), students are given ample time to design a physical prototype using everyday materials. Refer to slides 31-37 for resources to assist delivery of unplugged activity, including slides 35-36 to explore everyday material substitution guides.<br><br>**OR** | Refer to page 18-20 of the student workbook for instructions for plugged and unplugged activities.<br><br>Students engage in the CSIRO Robot Responders game via tablet, computer or internet enabled device.<br><br>Students can engage in unplugged activities.<br><br>Additional budget sheets:<br>Pages 15-17. |

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| | | Distribute CSIRO Robot Responders card game and provide ample time for students to play.<br><br>***Optional:*** teachers can assess student unplugged prototypes using the answer cards on slides 38-39.<br><br>***Optional:*** Plugged and unplugged – rubrics available on slides 40-43. | |
| ACT | **Slide 26**<br>**Page 2** | *Act Phase* – Explain the purpose of the act phase as using the findings to communicate, reflect, and apply to the real world. | Refer to page 2 to explore the 'Act Phase' in more detail, if required. |
| | **Slide 27**<br>**Page 24** | Lead the discussion reflecting on the students' robots in the Robot Responder game (Plugged and unplugged).<br>Answer and reflect as a class.<br>Students can then write their responses on page 24 in their student workbook. | Participate in whole-class discussion and complete page 24. |
| | **Slides 28-30**<br>**Pages 25-30** | *Teacher decides whether the 'Shark Tank' presentations are conducted in groups or independently (Plugged and unplugged).*<br><br>Slide 28 - Introduce the 'Shark Tank' presentation to the students. Their goal is to convince the class that their robot is the most successful at navigating space environments. | Students will use pages 25-30 to plan a 'Shark Tank' pitch and presentation. |

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| | | Refer to presenter notes for more information.<br><br>***Optional:*** Watch 'The Drip Drop Shark Tank;' video on slide 29 as an example of how to pitch.<br><br>Slide 30 - Explain how the students can present their campaign and communicate their initiative.<br><br>Students can use pages 25-30 to plan their presentations.<br><br>Allow students ample class time to plan, prepare and present their presentations.<br><br>Students can also assess one peer Shark Tank pitch and write their responses on page 29. | |
| | **Slide 44**<br><br>**Page 31** | Glossary | |

# Take it further

## Mission debrief & design iteration

After completing a mission in the game, students debrief as a group. The teacher starts a structured discussion where students reflect on their build choices, what worked, what ran out of energy or failed, and what they would change.

This connects the Robot Responders game experience to engineering design iteration, the idea that real engineers refine designs based on test results.

### Student steps:

- On a sticky note, write:
    - One component that helped you most in the mission.
    - One component you wish you had brought.
    - One component that is not in the game but would help in this mission.
- Class discussion:
    - Teacher collects the "most useful" components on the board. Which components appear most often? What does that tell us about the mission?
    - Teacher collects the "wish I had brought" components on the board. Which components appear most often? What does that tell us about the mission?
    - Teacher collects the "components that are not in the game" on the board. Which is the most unique? How will it help in the mission?

# *Optional*: EXAMPLE – Space– Lesson overview

Teachers can use this **example** set of resources of work to guide their planning. *Timings are subject to each school's individual context.*

| Lesson | Focus | Learning Activities | Plugged Option (Robot Responders online game) | Unplugged Option (Mission Cards & Physical Prototype) |
|---|---|---|---|---|
| **Lesson 1** | **Launch: What are Robot Responders?** | Introduce real-world robotics and CSIRO-inspired missions in caves, lava tubes, marine environments and space. Explore the engineering design process and mission constraints. | *N/A* | *N/A* |
| **Lesson 2** | **Investigate robot components** | Explore how sensors, movement systems and tools help robots operate in challenging environments. Analyse design trade-offs. | *N/A* | *N/A* |
| **Lesson 3** | **Inquire: Design solutions** | Apply the engineering design process to create a robot that meets mission requirements and budget constraints. | Students build and test a robot within the game, managing budgets and component selection. | Students analyse mission cards to identify environmental challenges and design requirements, investigate robot components, and develop annotated robot designs. They then create a prototype solution, apply budgeting constraints, and justify their design decisions based on the needs of the mission. |

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| **Lesson 4** | **Test, evaluate and improve** | Evaluate robot performance against mission criteria. Identify strengths, limitations and opportunities for improvement. | Students' complete missions, analyse results and modify their robot designs to improve performance. If unsuccessful, students redesign and retest. | Students construct a physical prototype using classroom materials and test it against teacher-selected mission challenges. Students refine their designs based on feedback. |
| **Lesson 5** | **Act: Present and reflect** | Communicate design solutions and reflect on the role of robotics in solving real-world problems. | Students present their final digital robot design, explain component choices and discuss mission outcomes. | Students present their physical prototype, explain how it addresses mission requirements and reflect on improvements they would make. |

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