Martian Rover Retrieval

Foundational | 45+ Minutes | Active | Basic | Robotics

In this activity, learners practice giving and following clear commands.

- "Programmers" give step-by-step instructions, directing "rovers" to retrieve objects around the room.
- As a class, learners create a short list of commands the "rovers" understand.
- Learners repeat the retrieval task using only those commands, first in real-time and then using pre-written programs to simulate how a robot would execute commands remotely.

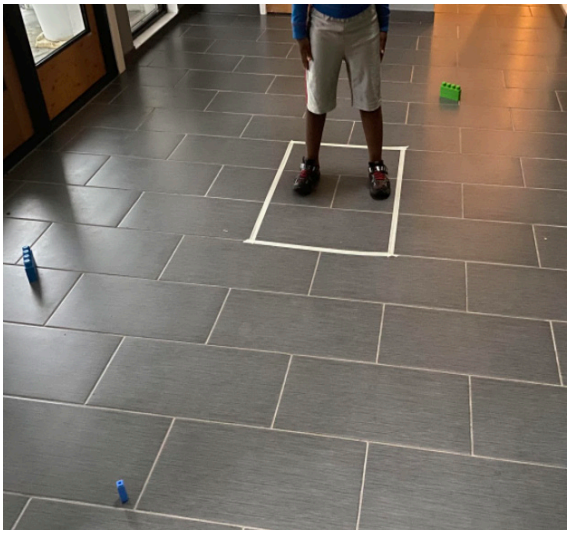

Image: An example setup, with a rectangle for the robot's home base and three "Mars rocks"

CT Learning Checkpoints

☑ Create clear commands to program a "robot" to collect objects

☑ Interpret commands to collect objects

Links & Materials

- Mars Rover Retrieval Folder
- "Mars rocks" (e.g., blocks, cans, balls of paper)
- Masking tape or other means of marking a location on the floor
- Optional: Means of projecting

Differentiation

- Place "rocks" closer together to make task easier.
- Provide non-verbal learners with index cards or slips of paper on which commands can be written.

Preparation & Setup

- Print copies (1 per learner) of the **Activity Sheet**.
- For each pair or team: Mark a rectangle to serve as the rover's home base (i.e., start/end position) and place three "Mars rocks" to be collected.

Set Up for Success

- Model how to do each Phase of the activity before having learners do them in pairs or teams. Consider choosing learners to demonstrate each Phase for the class (with your help and guidance).
- Introduce and review the Phase 2 table provided on the **Activity Sheet**.

  Explain that it is a tool that can be used to help learners keep track of:
  (1) the list of pre-determined commands that they come up with, and
  (2) what the robot does when it gets each command.
- Consider printing or projecting the list of **Example Commands** (PDF or Slides) for Phase 2, so learners can refer to them during that part of the activity.
- Offer **Word Cards** for learners who may need additional support with vocabulary.
- Introduce the **CT Learning Checkpoints** as goals learners should be working toward during the activity.

Activation

1. Engage learners with a short activity or hook: Choose a simple task like touching your nose or tying your shoe and have learners give you instructions for how to do it. Take their instructions literally to emphasize the importance of clear communication and sequencing of tasks.

2. Orient learners to the task: Play a game in which you have to get your partner to pick up objects around the room by only following your exact instructions.

   In this game, learners are part of a scientific team preparing to send a rover to Mars to collect rock samples. In order to explore Mars, they will have to use robots because it is not (yet) possible to safely send people. Learners will have to learn how to communicate with their "robot" so that it can successfully complete its mission on Mars.

3. Explain the purpose: To practice communicating with commands a robot can understand. This includes ideas such as:
   - Computers/machines (robots) do what we tell them to do through the process of **programming**.
   - Programs are made up of a set of **commands** (instructions to perform specific tasks).
   - The languages used to write computer programs are made up of small sets of commands that the computer can understand.
   - Programs are refined iteratively to fix mistakes (**debugging**).

4. Assign and explain learners' roles (expectation for self and others): This activity requires two participants. This can be two learners or one learner and one adult such as an educator. The participants in this activity each play a specific role:
   - The **programmer** creates instructions for the Mars rover "robot" to follow.
   - The "**robot**" must be attentive and listen carefully to the instructions, perform the instructions with the utmost precision, remain faithful to the instructions, and not try to correct the programmer.

   NOTE: If the players are one learner and one adult, the adult should play the role of the rover to allow the learner to practice giving instructions.

   Educators and other learners are expected to be patient and give the learner(s) the time and space to develop their own understandings and intuitions around what programming is. Likewise, they should act as supportive collaborators in jointly-pursued tasks, such as developing their own "robot language." Also note, this should be a fun, playful activity. Being silly in interpreting ambiguous commands can help keep things fun rather than becoming frustrating.

Procedures

Phase 1: Real-time Communication

Before sending a robot "rover" to Mars, scientists need to program it to perform the tasks for the mission. In this phase of the activity, learners will practice programmer/rover communication in plain language in real time.

1. Have the **programmer** give commands to the "**rover**," instructing them to pick up all three of the Mars rocks and drop them off at the starting position (home base). Learners can decide for themselves whether to have the **rover** bring rocks back to home base one at a time or all at once.
   - The person playing the **rover** stands at "home base."
   - The **programmer** gives instructions to the rover.
     - Note: The **programmer** shouldn't physically move or directly control the **rover** unless necessary (i.e., this is how the **programmer** best communicates in general).
   - The **rover** immediately follows each instruction, trying to do EXACTLY what the **programmer** says. For example, if the programmer says "move forward," the robot should immediately start moving forward and not stop until told to do so. (**NOTE:** This type of real-time instruction will become problematic later on, but is OK for now.)

2. Prompt learners to think of their role in this task: "What can you do to help yourself and your partner get better at this and similar tasks?" Ideally you want to elicit statements such as:
   - "I should be looking for tricks and strategies that we can use to communicate better."
   - "If my partner is confused about my instructions, I should try saying them a different way."
   - "If I am unsure about something we're doing, I should ask my partner or instructor to explain it to me."

3. If both the **programmer** and **rover** are learners, have them switch roles and repeat the activity so they each get a chance to practice giving commands.

Phase 2: Real-time Constrained Communication

1. Explain to the learners that robots do not understand all the words we use. Instead, robots only understand a small set of commands, so we need to come up with a list of commands that the robot understands.

2. Together, come up with a robot "vocabulary" – a list of **commands** the robot understands). Try to limit the number of commands to 10 or fewer. Learners should record the commands on the **Activity Sheet**.

3. Encourage learners to think about the different types of commands (and elements of those commands) they need to program the **rover**, such as:
   - Motion (e.g., move, walk, roll, turn)
   - Direction (e.g., forward, right, left)
   - Amounts/Numbers (e.g., how many steps)
   - Actions (e.g., pick up, bend over, open hand, close hand, drop)
   - Objects (e.g., rock)

4. Once the commands are written down, reset the objects and repeat the Phase 1 activity. This time, the **programmer** must only use words from the list of commands. **IF** they use a word that is not on the command list, **THEN** the **rover** should respond by saying, "I do not know how to ____."

5. After the **programmer** successfully gets the **rover** to collect all three Mars rocks, review the list of commands. Are there any commands that are not needed? Is there a way to shorten the list? For example, do you need "turn left" and "turn right"?

6. Have learners revise their command list, switch roles, and repeat the activity.

Potential Variation/Extension: Create multiple "languages" (different sets of commands). You can do this with different learners making their own languages. Then have them try several languages and compare how well they work.

Phase 3: Pre-defined Constrained Communication

1. Remind learners that Mars is very, very far away. So instead of giving the rover instructions one-at-a-time in real-time, the **programmer(s)** have to write the commands beforehand and send them to the **rover** all at once. The rover then follows each command in order. This is called **programming**.

2. Have pairs come up with a set of steps for the **rover** to follow in order to pick up all three of the Mars rocks and drop them off at home base. Have learners write out the steps on the **Activity Sheet**, using only commands from the list they generated in Phase 2.

3. Have the **programmer** give the **rover** the complete list of steps at once for how to pick up all three of the Mars rocks and drop them off at home base.
   - **NOTE: IF** any of the steps rely on doing something in real time (i.e., start/stop), **THEN** discuss why this approach won't work when writing a program beforehand. Work with the learner(s) to come up with a way to provide necessary details for the **rover**. In the end, you want to steer the learner toward defining fixed distances (e.g., "forward 3 steps" rather than using go/stop commands).

Debrief, Reflect, and Check for Understanding

1. Ask questions such as:
   - What did you find challenging or difficult about writing and following commands a robot can understand? How did you overcome those challenges?
   - Did you come up with any tricks or strategies to help control the rover?
   - Were you able to get your rover to pick up all the objects and return them to home base?
   - Did you use all the commands you had in your list? Did you need additional commands?

2. Encourage learners to share/talk about:
   - examples of some of the commands the **"programmer"** gave to the **"rover"** in Phase 1.
   - the vocabulary list of commands they came up with to program the **rover** in Phase 2.
   - the programs that they wrote in Phase 3.

3. Use the **CT Learning Checkpoints** to assess understanding and progress.

4. Use the **PRADA Prompts and Strategies** to review the computational thinking principles used in writing and following commands a robot can understand.

5. Collect and review the **Activity Sheets**.

PRADA Prompts and Strategies

Problem Decomposition

Breaking a problem or task down into smaller, more manageable parts

- What was the task you were trying to accomplish?
- How did you break the task down into smaller parts?

Algorithm Design

Designing a sequence of steps to be followed to accomplish a task or achieve some desired end(s)

- Why is the order of the commands given to a robot important? What would happen if the commands were given out of order

Abstraction

Identifying and focusing on the relevant parts of a problem or task to create generalizations

- How did you come up with a vocabulary/list of commands to direct the rover?
- What strategies from this activity can you apply to solving other problems?

Debugging

Systematically isolating errors in solutions to problems and then correcting them to achieve desired outcomes

- How did you change your instructions to help your partner successfully accomplish the task?