THE FRANKLIN INSTITUTE

Be a **Space Scientist!**

Be a **Robotics Engineer**

Educator Guide

Big Question: How can we design a rover's arm to scoop up soil and rocks?

GSK Science in the Summer™

In collaboration with GSK

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Be a Space Scientist! Big Ideas

These are the themes you'll find running through all five *Be a Space Scientist!* activities.

- ***Space science is about exploring and traveling outside our planet.*** *Space scientists study questions like:*
  - *What kinds of things are in the universe?*
  - *How can we learn more about them?*
  - *How might people (and other living things) travel or live in space?*
- ***Space is really big! Almost everything in space is too far away and hard to reach for space scientists to visit and study.*** *Instead they:*
  - *Use tools and machines to* ***gather information*** *and send it back to Earth*
  - ***Compare*** *what they see in space to things they know about on Earth*
  - ***Use models*** *to represent things that are too big, too small, or too far away to study directly*

Core Four Strategies

Use the Core Four Strategies as you guide your learners through this activity.

- **Ask questions** to spark curiosity and encourage new ideas
- **Encourage scientific thinking** with chances to observe, make predictions, and test ideas
- **Cultivate rich dialogue** with chances to talk together, share ideas, and use science words
- **Make connections** between learners' experiences, science careers, and this activity

Ask Questions

Encourage Scientific Thinking

Cultivate Rich Dialogue

Make Connections

Be a Robotics Engineer

Big Question: ***How can we design a rover's arm to scoop up soil and rocks?***

MATERIALS:

Per class:

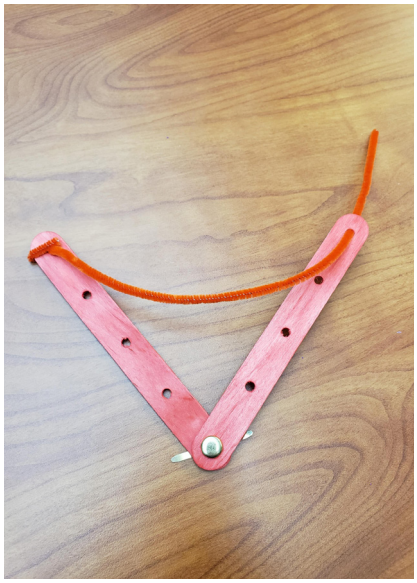
- Robotics engineer career card
- Plastic bins (4)
- Small pompoms (enough to cover the bottom of each bin)
- An assortment of building materials, such as:
  - Masking tape
  - Small paper cups
  - Plastic condiment cups
  - Construction paper
  - Paper clips
  - Small tart tins
  - Craft sticks with holes
  - Paper fasteners
  - Pipe cleaners
  - Scissors
- Lab notebooks
- Pencils
- Science skills stickers

Per pair of learners:

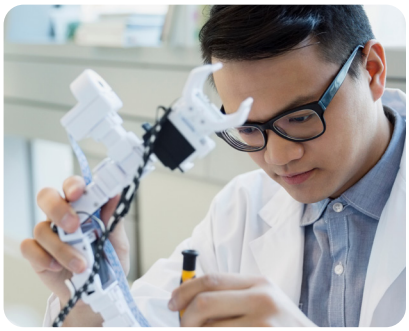
- Materials for robotic arm prototype:
  - Craft sticks with holes (2)
  - Paper fastener (1)
  - Pipe cleaner (1)

Prepare

1. Set up materials station(s): Set out the building materials (cups, tape, scissors, etc.) where learners can easily access and choose from them as they build their designs.
2. Make four testing stations: Add enough pompoms to each plastic bin to at least cover the bottom of the bin. Place the bins around the room where learners can easily access them for testing their designs.
3. Make an example robotic arm prototype:
   - Connect the ends of two craft sticks by putting a paper fastener through their end holes.
   - Thread one end of a pipe cleaner through the end of one of the craft sticks and fold the pipe cleaner over to secure it.
   - Thread the opposite end of the pipe cleaner through the end of the second craft stick, but don't fold it over.
   - Pulling the the loose end of the pipe cleaner should pull the opposite end of the other craft stick closer, like an arm bending at the elbow.



Engage



1. Introduce the robotics engineer career by showing the group the career card and asking questions to encourage students to think about what a robotics engineer might do:
   - *What do you notice about this picture? What do you think this person is doing?*
   - *Have you heard words like "robotics" or "engineer" before?*
   - *What do you think a robotics engineer might do or study?*

2. Introduce the storyline like this:
   - We're part of a team designing a rover to explore Mars. The rover will drive around on the surface and collect samples of rocks and soil to send back to Earth.
   - Rovers are really complicated and have lots of parts! Different teams of engineers are working on different parts of the rover.
   - Our team is assigned to designing the scoop that will scoop up the rocks and soil.

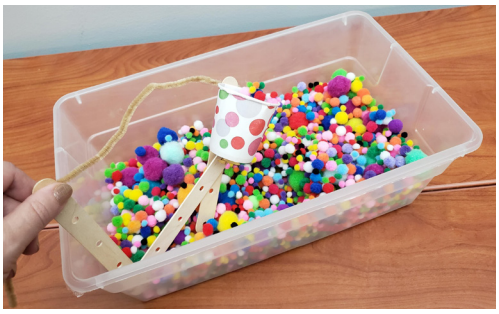
3. Ask the group to look at the images of robotic rovers on page 13 of their lab notebooks.
   - *What parts of the rover do you think might help collect soil or rocks?*
   - *How do you think they work? What would they do?*
   - *Where would the soil or rocks be stored to take back to Earth?*
4. Ask the group to think about how a scoop works and what parts it has. Invite them to use the example photos on page 14 of their notebooks for ideas.
   - *What things can you think of that scoop something up?*
   - *How do those things work? What parts do they have? What motion do they use?*
   - *Looking at some of these examples, what things do they have in common?*

Explore

Part 1: Build Arm Prototype

1. Explain that another team has already started working on the arm part of the scoop. Introduce the arm prototype and demonstrate how it could work to reach out and pull something inward.
   - *If this were attached to a rover, how could it help collect soil or rocks?*
   - *Our job is to design a scoop that will go on the end of this arm*
2. Divide the group into pairs and pass out materials for the arm. Walk the whole group through assembling the arm prototype:
   - Line up the two sticks and put the paper fastener through the end hole of both together
   - Fasten the pipe cleaner through the opposite end of one stick
   - Thread the other end of pipe cleaner through the end of the other stick
3. Give learners an opportunity to practice operating the arm.

Part 2: Scoop Design



4. Show the group the testing bins. Explain that the pompoms represent the soil or rocks the rover needs to scoop up. Their goal is to design a scoop for the end of the arm so that they can use the arm to successfully scoop up pompoms.
5. Show the group the building materials. Allow time to design, build, and test their scoops.
6. As they work, encourage learners to keep testing and redesigning their scoop. Provide prompts that challenge them to extend and improve on their designs:
   - *How could you design it to pick up as many "rocks" as possible?*
   - *Once the rocks are scooped up, how will the arm get them back to the rover for storage?*
   - *Can you redesign it so the robotic arm does all the moving, and not your arms?*

Younger learners may have trouble controlling the motion of the arm prototype to create the scooping action. They can focus on designing a scoop attachment that successfully collects "rocks," even if it doesn't use the bending motion of the arm.

Reflect

1. Gather the whole group together. Invite each pair to demonstrate their design for the group.
   - *How did you end up with this design?*
   - *What did you try that didn't work?*
   - *How would you improve it even more if you had more time or different materials?*
2. Discuss the results of the team's research:
   - *What do our designs have in common?*
   - *What should we tell our rover team about how to build a scoop for the robotic arm?*
3. Encourage the group to reflect on how they were like robotics engineers during the activity. Refer to the career card and the science skills stickers:
   - *What are some of the things we did today as robotics engineers?*
   - *How did we think like scientists? What science skills did we use?*
   - *What did you do today that made you feel like a scientist?*
4. Allow time for students to draw or write their reflections on page 15 of their lab notebooks. Invite them to choose a science skills sticker that reflects a skill they used and add it to their notebooks.

Background

- Robots are not just the metal people we see in science fiction stories! **A robot is any machine that can be programmed to carry out a series of complex actions automatically.** Robotic machines are used to assemble cars in factories, move products around warehouses, assist doctors with surgery, and even vacuum our floors.
- **Robotics engineers** research, design, and test robotic systems. That might include building the mechanical parts of a robot, designing the electronic wiring and circuits that operate it, or writing the software that gives the robot its instructions.

- **Robotic machines are an important tool for exploring space,** since they can go where humans can't! Satellites, Mars rovers, and the International Space Station all contain robotic parts that perform tasks in space. Engineers on Earth control them by sending instructions to their computer systems via radio waves.
- NASA has sent five different rovers to explore Mars. All have used their robotic tools to gather information about the planet, from taking photos to measuring weather conditions to detecting Mars-quakes. **The Perseverance rover, launched in 2021, includes a robotic arm for drilling and collecting rock samples, like the one modeled in this activity.** Perseverance's samples won't be returning to Earth yet, though. The rover is leaving them at a specific drop location on the Mars surface, where future missions will find and pick them up.

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Robotics Engineer Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
ENGAGE		
Introduce Career • Use career card • Ask discussion question • Explain what robotics engineers do	*What do you notice about this picture?* *Have you heard "robotics" or "engineer" before?* *What do you think a robotics engineer does in their job?*	• Make observations about the image • Make connections to their own experience • Share their ideas
Introduce Story • We're part of a team designing a Mars rover • We will design the scoop for collecting rocks and soil	*What parts of the rover do you think might help collect soil or rocks?* *How do you think they work? What would they do?*	• Imagine being robotics engineers • Look at rover photos • Discuss parts that might collect samples
Discuss Scoop Design • Refer to scooping tool photos in student lab notebooks	*What things can you think of that scoop something up?* *What parts do they have? What motion do they use? What things do they have in common?*	• Connect to prior experience with scooping tools • Discuss ideas about common features of scooping tools
EXPLORE		
Part 1: Arm Prototype • Demonstrate arm prototype • Direct groups in building arm prototype	*If this were attached to a rover, how could it help collect soil or rocks?*	• Build arm prototype • Practice using arm prototype
Part 2: Scoop Design	*How could you design it to pick up as many "rocks" as possible?* *Once the rocks are scooped up, how will the arm get them back to the rover for storage?* *Can you redesign it so the robotic arm does all the moving, and not your arms?*	• Design and attach scoop to arm • Test scoops in testing bins • Redesign & improve

***Quick Guide continues on the following page.*

Robotics Engineer Quick Guide

EDUCATORS DO:	EDUCATORS ASK:	LEARNERS DO:
REFLECT		
Share Group Results	*How did you end up with this design? What did you try that didn't work?* *What should we tell our rover team about how to build a scoop for the robotic arm?*	• Draw conclusions • Make recommendations
Make Career Connections	*What did you do today that made you feel like a robotics engineer?* *How did we think like scientists? What science skills did we use?*	• Use skill stickers • Draw/write reflections

Notes

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