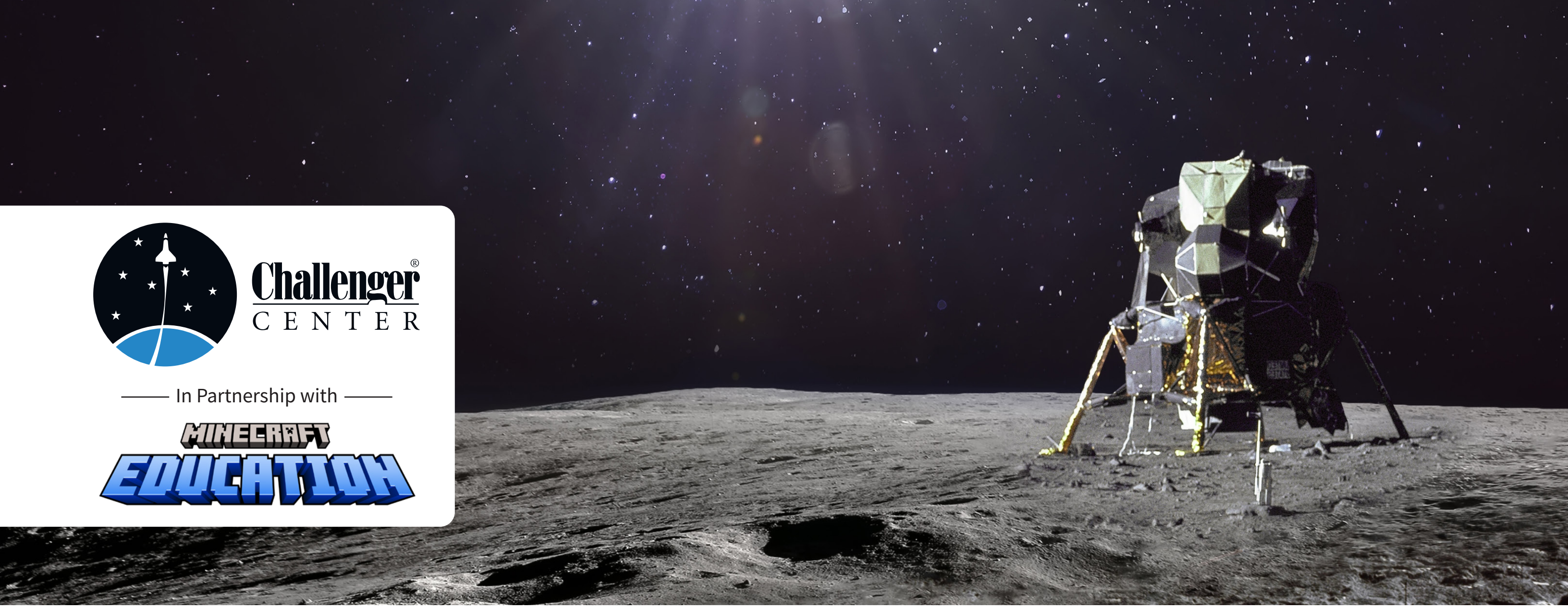

Lunar Lander Challenge

Design a Lunar Lander Prototype

LESSON OVERVIEW

NASA's Artemis program is taking people to the Moon. So, how will they deliver astronauts and cargo to the surface? This team design challenge will help students find out.

Students will work in teams across separate zones to design a lunar lander that can safely and accurately deliver cargo to the surface of the Moon.

Student Ages

8-13

Subjects

Art and Design
Science
Teamwork

Skills

Communication
Planning and Investigation
Teamwork

Estimated Time

55-60 minutes

Educational Settings

Classroom
Informal *(museums, science centers, and camps)*

LEARNING OBJECTIVES

Students will . . .

- apply aspects of the engineering cycle to create a prototype lunar lander,
- understand the importance of good communication in working with team members at different locations, and
- compare solutions to a problem to determine the best lunar lander design features.

TEACHER NOTES AND PREP

Background

The last time humans went to the moon was in 1972 as part of NASA's Apollo program. But recently, NASA was charged with taking the first woman and first person of color to the moon in a new program named Artemis. In 2022, NASA launched Artemis I, an uncrewed mission to test the rocket. In 2024, the Artemis II mission will be the first crewed Artemis mission.

As part of the Artemis program, astronauts will soon be living and working on the Moon's surface. But first, they'll need to design a lander that can safely transport the astronauts to the surface so they can start building the base.

Because the Moon has almost no atmosphere, a parachute won't slow down cargo as it hurtles toward the surface. Instead, shock-absorbing landers will help bear the load. These may include struts, airbags, springs, cushions, and more to help disperse the force of hitting the ground.

The teams of engineers working on the lander must work together from across the country and all over the world to coordinate their projects. This kind of collaboration is a crucial, yet tricky skill. This lesson gives students a taste of long-distance teamwork.

Preparation

There are many ways to adjust this lesson to meet the needs of your students or space. The core of the lesson (designing, building, and testing) remains the same throughout.

Communication Across Spaces

This lesson is designed with students simultaneously working in two different "zones." The added teamwork challenge is that groups must communicate between zones. Depending on what is available, you may have teams communicate between zones using:

- Walkie-talkies
- Laptops or tablets with video call software
- A designated student "communicator" on each team who is allowed to cross between the zones and verbally deliver instructions and questions.

Activity Zones

How you divide up your zones for this activity is very flexible. You simply need two areas that are separated by a little bit of distance. Below are just a few examples of how to divide these zones up based on your space:

- A "Build Zone" on one end of your classroom and a "Landing Zone" on the other end of your classroom.
- A "Build Zone" in your classroom and a "Landing Zone" in an other teacher's classroom.
- A "Build Zone" in your classroom and a "Landing Zone" in a multipurpose room.
- A "Build Zone" in your classroom or multipurpose space and a "Landing Zone" outside.

Adjusting Activity Level

For more advanced groups, you can include the budget element listed in the plan (where students have an allotment of tokens to spend on design supplies at a "store"). A sample pricing sheet is included in this lesson, including blank space where you can determine your own supplies and prices. To communicate, have teams split up across the two zones as listed in the plan. Teams will be challenged to effectively communicate their designs from space to space.

For younger groups, you can do away with the budget and allow students to access as much of each supply as they desire. For the youngest students, you may decide to give each group a standard set of supplies and do away with the "store" concept all together.

Communication is key! For more advanced groups, split into two zones as listed in the plan and challenge teams to effectively communicate their designs from one zone to the other. For younger groups, start by having everyone work together in the "Build Zone" to design a prototype. Then, move as a group to the "Landing Zone" to test your design.

Arranging the Room

Arrange your "Build Zone" and "Landing Zone" in separate locations:

- *Build Zone:* Set out supplies in a central "store" location. Give groups ample area (table or floor space) to build their prototypes.
- *Landing Zone:* Set up a Drop Zone. This can be over a railing outside, off a step ladder, or even over a balcony in a taller space (higher drop = more challenging). Place a target (you can use a tarp, bucket, or the included printable Drop Target) at the bottom of your drop zone. If you are having groups communicate across spaces, set up a supply location that matches the "store" in the Build Zone.

STUDENT ACTIVITIES

Supplies

For each group of four students:

- One small "astronaut" to fit in cup (e.g., a marshmallow, toy car, or even an egg if you're daring!)
- One disposable cup (foam or plastic)
- Pencil
- Communicator (e.g., walkie-talkie, laptop or tablet, or "Communicator" badge you assign to one student per group)
- Sheet of paper for brainstorming (optional)
- Tokens for "currency" (e.g., pennies, candies, craft sticks, washers, or any other small object)

For the "Store"

All supplies are suggestions and can be substituted as necessary. Use your discretion of quantity based on group size, but plan for groups to use several of each:

- Cotton balls
- Index cards
- Pipe cleaners
- Rubber bands
- Straws
- Squares of cardboard
- Tape (cut into ~8in/20cm strips)

Warm-Up and Introduction (5-7 minutes)

- Begin by showing students the picture of Rene Ortega, Chief Engineer for NASA's Human Landing Systems Program (see External References for link). Mention that Rene came from Nicaragua to America and became inspired by space at a young age.
    - Ask students: What do you think the chief engineer for a Human Landing Systems program works on? Landing where?
- Next, show the 2-minute video, *Meet the Artemis Team*. If you don't have the ability to show a video, check out the External Resources section for some info on Artemis and then share a few facts with students.
    - Ask students: What did you notice about the Artemis program?
- Highlight that the mission is going to bring people to live on the Moon, and that individuals from all over the world are working together to make this happen. Tell students that today, they will be teams of engineers working on the Human Landing Systems program to build a lunar lander of their own.

Explain the Challenge (10 minutes)

- Ask the class to brainstorm things that would be important to think about when designing a lunar lander. If possible, write the responses down for all to see. Responses might include:
    - Landing accurately (not far away!)
    - Landing slowly/safely
    - Lightweight materials
    - Having enough room to hold cargo
- Divide students into teams of four. Then, divide each team of four into pairs: a Design Pair and a Landing Pair.
- Explain that teams must build a lander that can protect their "astronaut" and land it as accurately as possible when dropped into a Landing Zone.
    - To survive, the astronaut cannot be damaged or pop off the lander.
    - The astronaut must ride in the cup "capsule," and the cup must remain upright.
    - Teams cannot completely seal off the top of the cup, as the astronauts need to be able to see out the top of the capsule.
    - Mention that the moon has so little atmosphere (air) that parachutes are ineffective, so this challenge cannot include parachutes. Space agencies must focus on cushioning the fall of a lander with struts, airbags, springs, cushions, and more.
- Teams will have up to 20 minutes to design and build their lander using the provided supplies, with a long-distance twist.
- Design Pair teammates will work to build the lander prototype, but will not have access to the Landing Zone or know what it is like. Their job is to create a prototype, then communicate with their Landing Pair teammates to tell them how to build the prototype.
    - Design Pairs will have a budget of 25 tokens they can spend at the store for their designs.
    - Communication will be through your pre-determined method: walkie-talkies, tablets, laptops, or a team member designated as the "Communicator" who can walk from zone to zone.
- Landing Pairs will be stationed at the Landing Zone. Their job is to build a lander based on the instructions coming from their Design Pair teammates. They are also allowed to talk to the Design Pair about the Landing Zone.
- When time is up, teams will all come to the Landing Zone together to test their landers.

Design Challenge (15 minutes)

- Confirm that teams understand the challenge and field any questions.
- Begin the timer and let teams start to build.
- Monitor the store to ensure students are getting fair access to supplies.
- Move about the Zones, providing facilitation and feedback to groups as needed. Ask:
    - What do you have in mind for your design? How did you come up with it?
    - How will you protect your astronaut?
    - How will you make sure your lander goes where it is supposed to?
    - What is challenging for you? How can you overcome this? What do your teammates think?

Testing (10 minutes)

When time is up, gather everyone at the Landing Zone. One at a time, drop each team's lander. Determine if the lander was successful:

- Was it close to the bullseye?
- Was the astronaut delivered to the surface safely?

Return each group's lander, but do not have them take it apart yet!

Regroup and Final Discussion (15 minutes)

Regroup as a class and discuss the tests:

- How many landers were successful? What features did they have in common?
- What would you do differently if you could change your design?
- What challenges did you face in designing or communicating? How did you overcome them?
- How do you think these are similar to the challenges faced by engineers working on the Artemis moon lander?
- If our class were going to propose ONE lander design based on these tests, what features would we want to include in our report? Why?
- Finally, congratulate your engineering teams on their work. Sometimes the hardest part of the engineering process is designing a first prototype!

Optional Continuation

If time permits, the best next step is to have teams modify their landers for another round of testing. The same discussion questions can be used at the end to compare the new iterations of landers created. The engineering process is cyclical, and this is a valuable way to illustrate it.

GUIDING IDEAS AND QUESTIONS

- What features does a lunar lander need?
- How can a design absorb shock and land accurately?
- How can groups communicate effectively across zones to succeed at a challenge?

PERFORMANCE EXPECTATIONS

Students will . . .

- gain hands-on experience with aspects of the Engineering Design Cycle as they work together to create moon landers, and
- develop social/emotional literacy as they work to maintain positive communication with team members to complete the design challenge.

NGSS SCIENCE AND ENGINEERING PRACTICES

For educators based in the United States, the Next Generation Science Standards (NGSS) Science and Engineering Practices in this lesson are:

- planning and carrying out investigations;
- constructing explanations and designing solutions; and
- engaging in argument from evidence.

EXTERNAL REFERENCES

NASA | How We Are Going to the Moon
https://youtu.be/_T8cn2J13-4

NASA | I Am Artemis: Rene Ortega
https://www.nasa.gov/feature/i-am-artemis-rene-ortega

NASA | Meet the Artemis Team
https://youtu.be/BC5khqpKovU

NASA | NASA Locations, Capabilities, and Points of Contact
https://www.nasa.gov/partnerships/contact.html

Seeker | NASA's 2024 Artemis Moon Landing Mission Explained
https://youtu.be/B2lA3Uu29KI

Time Me | Countdown Timer
https://www.timeme.com/countdown-timer.htm

SUPPORTING FILES

- Vocabulary List
- Price Sheet
- Drop Target
- Teacher Prep Video: https://youtu.be/5ob2nwoe064

EXTENSIONS

ENGINEERING EXTENSION

We'll need to not only deliver astronauts to the Moon's surface but also send supplies to build with, requiring a lander that can deliver larger loads. Replace the "astronauts" from this challenge with a larger piece of cargo (e.g., balloons, multiple toy cars, etc.). Challenge groups to test their original lander design with this new cargo, then alter the design to improve the lander's safety and landing accuracy.

LANGUAGE ARTS / WRITING EXTENSION

Write an "Assembly Process Writeup" (a set of directions for how to build your team's lander design) that you can give to another team of engineers. Focus on correctly sequencing the building steps. Make the steps precise and descriptive so someone else can build the lander correctly according to your design without seeing the original. Optional: Have teams swap writeups and attempt to build a lander based on the instructions they're given.

MATH EXTENSION

Test the class' landers again. This time, measure how far each lander fell from the center of the drop target. Chart these results for the class to see. Then, calculate the average distance from target for the entire class. You can also have teams test their own lander several times, measuring each attempt and finding their team's individual average. Whose lander was the most precise?