NESSP Mini-Mission

Artemis ROADS

We are going back!

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About Northwest Earth and Space Sciences Pathways

The Northwest Earth and Space Sciences Pathways (NESSP) brings NASA science to K-12 students throughout the Northwest. Funded through NASA's Science Mission Directorate, NESSP's (pronounced "NESPy") goals are to strengthen science, technology, engineering, and math (STEM) education region-wide and to serve as a bridge into other NASA experiences for educators and students.

NESSP's programming is available to communities across the Northwest region. We especially welcome relationships with educators from underserved and rural communities to cocreate STEM exploration opportunities.

Through our ROADS national student challenges, we also offer our programming to students and educators across the United States.

Contact NESSP

NESSP is headquartered at Central Washington University in Ellensburg, Washington.

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Partner

We want to see NESSP in action!

Share photos, videos, and comments related to your experience by emailing us or tagging us on social media:

- Email: info@nwessp.org
- Instagram, Facebook, YouTube and Twitter: @nwessp

About Artemis ROADS Mini-Mission

Our ROADS program (Rover Observation And Discoveries in Space) is a framework that lets students explore STEM concepts through hands-on activities. ROADS takes inspiration from real NASA projects and guides students on space-related missions. Each year we update ROADS to tackle different science and engineering problems and to visit different solar system bodies. For the 2022-2023, 2023-2024, and 2024-2025 challenges, we returned to the Moon to inspire students with NASA's Artemis Missions.

Activities:

- Observe the Moon and learn about lunar phases
- Build a terrarium to learn about life in closed systems
- Explore the surface of the Moon, including craters and challenges for rovers
- Explore what they would pack on a long trip to the Moon to stay happy and healthy
- Robotics & programming — program and design a rover capable of driving on the Moon and in lunar tunnels.
- Follow the Engineering Design process when building and testing a water bottle rocket.
- Design and build a lunar habitat for four astronauts.
- Design and build a water purification device for lunar astronauts.

Materials:

A primary goal of NESSP is to provide supplies and experts to educators in underserved communities. To support these mini-mission, most hard to acquire or expensive materials needed to complete the activities are available can be loaned (see the Appendix for details) to registered mini-mission instructors.

Stipends for Mini-Mission Instructors:

NESSP will provide stipends to instructors and co-instructions leading a week-long mini-mission.

- 8 to 15 students: One $2,500 stipend for the instructor
- 15 to 30 students: One $2,500 stipend for the lead-instructor and a $1,500 stipend for a co-instructor

To register for stipends, instructors must complete the associated three hour training to be scheduled in May and June and submit the online registration form.

Resources for additional information:

Learn more about the Artemis Mission:

- Introduction to Artemis: https://nwessp.org/a-roads-introduction-to-artemis/
- NASA's Artemis Webpage: https://www.nasa.gov/artemisprogram

Providing feedback, corrections, and success stories:

NESSP strives to develop material and programs that are effective for teachers and students. You will be contacted by our official evaluator, Horizons Research, Inc., and asked to provide feedback.

Getting Started

Team Descriptions and Selections

At the start of camp, divide students into groups of three to five. These groups should remain consistent throughout the week, as teamwork and task delegation are essential skills for any mission. When forming teams, try to distribute students with experience in robotics and programming evenly.

Establish clear guidelines for how students should interact with each other and with you. Monitor group dynamics to ensure that all students actively participate in every aspect of the project. Assigning leadership roles—such as science lead, robotics lead, or drone lead—can help ensure that every student has a meaningful role.

Engaged students are happier than bored ones! Keep them busy, but also be mindful of their energy levels. Provide breaks as needed, and if necessary, swap out some educational blocks for fun activities (pool time, anyone?) or allow more time for programming robots or tackling mini-missions. Adjust as needed based on what works best for your student

Mission Overview

We have adapted some of the most engaging and appropriate **Mission Objectives** and **Companion Course** lessons from the following Artemis ROADS challenges to create this advisor's guide: **2022-2023 Artemis ROADS, 2023-2024 Artemis ROADS II, and 2024-2025 Artemis ROADS III.** The activities include a mix of science, engineering, and creative tasks. For each activity, we provide links to the corresponding Companion Course lesson for additional resources or background information. **Lecturing is discouraged**! Students should focus on hands-on experiences rather than passive learning. Most importantly, it should be fun!

Suggested Camp Schedules

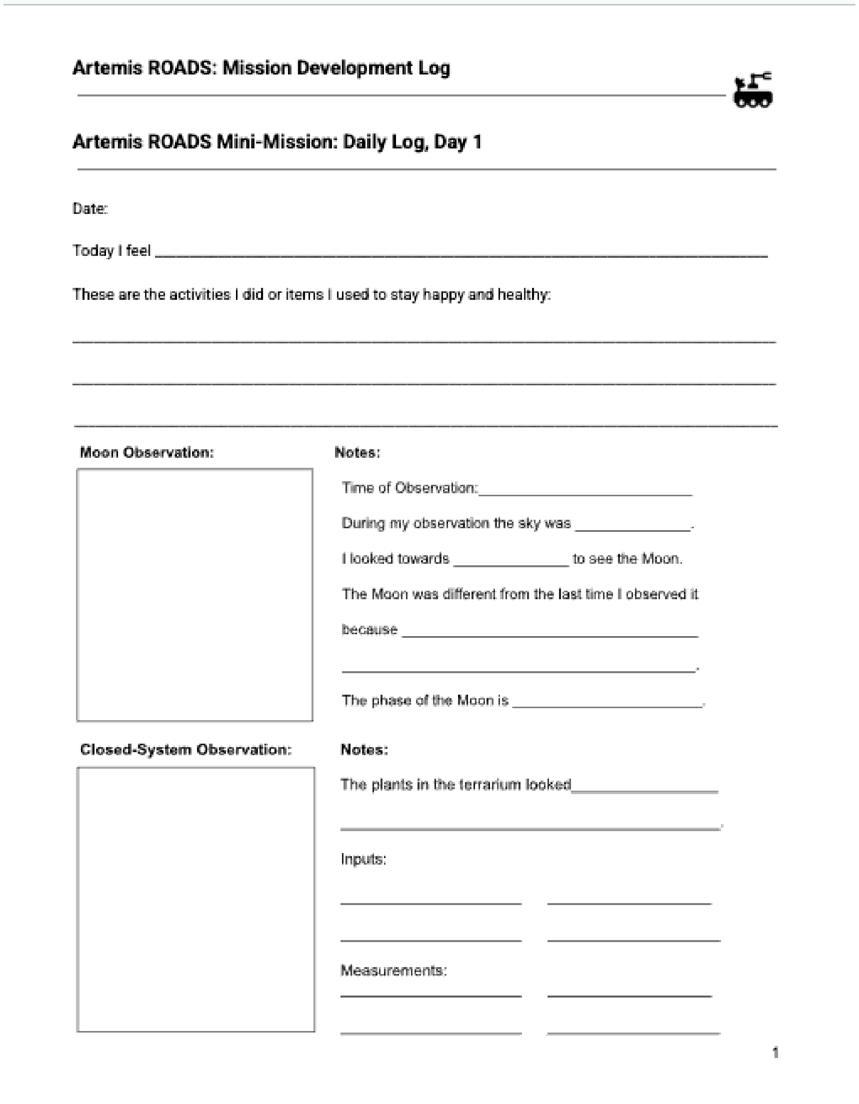
Below are several **Mini-Missions** you can include in your camp. Choose the ones that best fit your students, available time, and resources.

- **Mini-Mission 1: Artemis Lotería (new for 2025)** – A bingo-like game to introduce students to NASA, the Moon, and the Artemis mission.
- **Mini-Mission 2: Destination Moon** – Students make daily Moon observations and explore the reasons for lunar phases.
- **Mini-Mission 3: Life in a Closed System** – Students study closed systems (e.g., Biosphere 2, space habitats) and design an experiment.
- **Mini-Mission 4: Pack Your Moon Kit** – Students journal about personal objects they would bring on a trip to the Moon.
- **Mini-Mission 5: Investigate the Moon's Surface** – Students examine the challenges of sending rovers and humans to explore the Moon.
- **Mini-Mission 6: Rover Development & Surface Navigation (updated for 2025)** – Students build and program a lunar rover to complete an engineering challenge.
- **Mini-Mission 7: Craters on the Moon** – A hands-on activity to explore how lunar craters are formed.
- **Mini-Mission 8: Getting to the Moon** – Students build and test a water bottle rocket.
- **Mini-Mission 9: Build a Habitat** – Students design and construct a lunar habitat using lunar regolith simulant and a 3D pen.
- **Mini-Mission 10: Build a Water Purification Device (new for 2025)** – Students study Earth's water cycle and design a purification system for the Moon.
- **Mini-Mission 11: Mission Patch** – Teams design a custom mission patch.
- **Mini-Mission 12: Mission Readiness Review** – Students present their work to fellow campers, families, and the community (if invited).

Note: No one-week camp can cover all of these activities. So please don't try to do them all!

Student Workbook

An optional student workbook is provided for campers to document what they learn throughout the week. The workbook is in Google Docs format, allowing you to edit, adjust, or remove components as needed.



Artemis ROADS: Mission Development Log

Artemis ROADS Mini-Mission: Daily Log, Day 1

Date:

Today I feel ______________________________

These are the activities I did or items I used to stay happy and healthy:

____

____

____

Moon Observation:

Notes:

Time of Observation:______________

During my observation the sky was __________.

I looked towards __________ to see the Moon.

The Moon was different from the last time I observed it

because ______________________

______________________.

The phase of the Moon is ______________.

Closed-System Observation:

Notes:

The plants in the terrarium looked__________

______________________.

Inputs:

__________ __________

__________ __________

Measurements:

__________ __________

__________ __________

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Suggested Schedule

The example schedules below are organized into a series of educational blocks, each described in this manual. The colors indicate different "flavors" of activities, and mixing them gives your students variation. We have also included alternative versions with built-in flexibility for additional educational or recreational activities.

Additional example schedules can be found in the Google Sheets document linked below. Feel free to copy a schedule and adjust it to suit your camp's needs:
Artemis ROADS Mini-Mission Schedule(s)

While the schedule is adaptable, all mini-mission advisors are encouraged to include some of the rover/programming activities, as it introduces students to coding and the engineering design process.

Example 1:

A	B	C	D	E	F
Time (9 hours)	Day 1	Day 2	Day 3	Day 4	Day 5
15	Logistics (could include things like sign-ins, group assignments, welcome, etc)	Logistics	Logistics	Logistics	Logistics
15		Sharing Moon Observations	Sharing Moon Observations	Sharing Moon Observations	Sharing Moon Observations
30	Intro to the Challenge	Mini-Mission 4: Investigate the Moon's Surface (Engage, Explore)	Mini-Mission 6: Craters	Mini-Mission 3: Pack Your Moon Kit (Explore, Explain)	Mini-Mission 2: Life in a Closed System (Explain)
30					
30	Mini-Mission 1: Destination Moon (Engage, Explore)				
30		Mini-Mission 5: Rover Development and Surface Navigation (Engage, Explore)	Mini-Mission 5: Rover Development and Surface Navigation (Challenge 2)		Final Presentation/Surface Navigation Rehearsal
30				Mini-Mission 7: Mission Patch (Explore)	
30					
45	**Lunch**	**Lunch**	**Lunch**	**Lunch**	**Lunch**
30	Mini-Mission 2: Life in a Closed System (Engage, Explore)	Mini-Mission 2: Life in a Closed System	Mini-Mission 2: Life in a Closed System	Mini-Mission 2: Life in a Closed System	Mini-Mission 8: Final performances and Presentations
30		Mini-Mission 5: Rover Development and Surface Navigation (Explore, Challenge 1)	Mini-Mission 7: Mission Patch (Engage)	Mini-Mission 1: Destination Moon (Explain, Elaborate)	
30					
30			Mini-Mission 5: Rover Development and Surface Navigation (Challenge 2/Challenge 3)	Mini-Mission 5: Rover Developmment and Surface Navigation OR Flex Time (Challenge 3)	Awards and Celebrations
30					
30					**Pick up / dismissal**
30				Educators Choice: Alternative activity, fun time, career exploration, and/or tie-dye	
30	Mini-Mission 3: Pack Your Moon Kit (Engage)	Prepare for moon observations. Reminder to journal for Moon Kit.	Prepare for moon observations. Reminder to journal for Moon Kit.		
15	Closing: Checking back in on question list	Closing: Checking back in on question list	Closing: Checking back in on question list	Closing: Checking back in on question list	
30	**Pick up / dismissal**	**Pick up / dismissal**	**Pick up / dismissal**	**Pick up / dismissal**	

Example 2:

Time (9 hours)	Day 1	Day 2	Day 3	Day 4	Day 5
15	Logistics (could include things like sign-ins, group assignments, welcome, etc)	Logistics	Logistics	Logistics	Logistics
15		Sharing Moon Observations	Sharing Moon Observations	Sharing Moon Observations	Sharing Moon Observations
30	Intro to the Challenge	Mini-Mission 7: Getting to the Moon	Mini-Mission 5: Rover Developmment and Surface Navigation	Mini-Mission 3: Pack Your Moon Kit (Finish)	Mini-Mission 7: Mission Patch (finish)
30					
30	Mini-Mission 1: Destination Moon				Final Presentation/Surface Navigation Rehearsal
30					
30				Mini-Mission 7: Mission Patch	
30					
45	**Lunch**	**Lunch**	**Lunch**	**Lunch**	**Lunch**
30	Mini-Mission 8: Build a Habitat	Mini-Mission 7: Getting to the Moon	Mini-Mission 5: Rover Developmment and Surface Navigation	Mini-Mission 1: Destination Moon (Finish)	Mini-Mission 8: Final performances and Presentations
30					
30					
30				Mini-Mission 5: Rover Developmment and Surface Navigation OR Flex Time	Awards and Celebrations
30					
30					**Pick up / dismissal**
30				Educators Choice: Alternative activity, fun time, career exploration, and/or tie-dye	
30	Mini-Mission 3: Pack Your Moon Kit	Prepare for moon observations; make predictions and record in MDL. Reminder to think about Moon Kit.	Prepare for moon observations; make predictions and record in MDL. Reminder to think about Moon Kit.		
15	Closing: Checking back in on question list	Closing: Checking back in on question list	Closing: Checking back in on question list	Closing: Checking back in on question list	
30	**Pick up / dismissal**	**Pick up / dismissal**	**Pick up / dismissal**	**Pick up / dismissal**	

The Mini-Missions

Mini-Mission 1: Artemis Lotería

Full Lesson: https://nwessp.org/lesson/artemis-iii-1/

Estimated Time: 1 hour

Summary: *Students will learn more about the Artemis missions by playing a Lotería game.*

Students can explore the Artemis missions by playing Lotería, a popular Mexican game similar to Bingo. Instead of numbers, Lotería uses illustrated cards and playing boards (tablas). A caller randomly selects a card, announces it by name or description, and players check their boards for a match, covering it with a marker. The first player to cover their entire board shouts **"¡Lotería!"** and wins.

Game Levels:

- **Level 1 (easiest):** Show the image and read its name.
- **Level 2:** Show the image, read its name, and read the information on the back.
- **Level 3 (hardest):** Read only the information on the back—do **not** show the image or read the name. This encourages students to learn and recall key facts.

We will send a printed version of the game. Students can also try our **online version** of the game here.

Mini-Mission 2: Destination Moon

Full Lesson: https://nwessp.org/lesson/artemis-roads-unit-1-lesson-3-destination-moon/

Estimated Time: 2.5 hours

Summary: *Students share their prior knowledge of Moon phases before making use of a simulator to understand phases are related to the location of the Earth, Moon, and Sun. Students will also be encouraged to make nightly observations of the phases of the Moon.*

Engage (30 minutes): Students will share their prior knowledge of the Moon phases in their everyday experiences at home or school.

First, prompt students to "Think of a time when you saw the Moon. What did it look like?" Give students ten minutes to share as a table talk or partner share. Encourage students to describe in detail what they saw or noticed about the Moon at home or school. Think about how they experience the Moon locally:

- Can you ever see the Moon while you are at school?
- Where is an ideal place around here to go see the Moon?

Next, play the video showing Moon Phases from 2025:
(2025 Moon Phases - Northern Hemisphere - 4K).

After the video, give students ten minutes to pair share what they noticed in the video and what they are still wondering. Generate a class list of questions that students are still wondering about the Moon and its phases.

Explore (30 minutes): Students will make direct or indirect observations of the Moon to track phases and make predictions.

Tell students that they will be making Moon observations at the same time every day throughout the week. They should draw the Moon clearly to show the light and dark portions. You can help students prepare for this observation by looking up the Moon's rise and setting times for your local area at a website like https://www.timeanddate.com/moon/. If the weather is not cooperating, tell the students to infer what the lunar phase might look like based on their other observations. If needed, you can also have them look up the phase online.

Some questions to engage the students about their observations during the morning sessions:

- What patterns or trends are you noticing?
- What do you notice about the change in illumination or shadow of the Moon's surface?
- Can you use your observations to predict the next lunar phase?
- Why can we see the Moon sometimes during the day and at night?
- How is the Moon's proximity to the Sun in the sky related to its phase?
- Explain why everyone on Earth sees the Moon as the same phase on the same day?

Explain (30 minutes): Students will use a Sun/Earth/Moon orbit simulator to explain the Moon phases and its orbit.

Students need laptops/computers to access the Sun/Earth/Moon simulator website. If possible, assign students in pairs.

Simulation link:
https://contrib.pbslearningmedia.org/WGBH/buac19/buac19-int-earthsunmoon35model/index.html

Display the slides for this mini-mission from the resources folder to help students understand the different perspectives and representations of the Sun/Earth/Moon simulation.

- Slide 1: Point out to students that there are two perspectives, the top is the perspective on Earth in the Northern Hemisphere, and the bottom is the perspective in space, looking down on the north pole.
- Slide 2: Tell students the key features: sunrise/moonrise, sunset/moonset, and day/night.
- Slide 3: Point out the different tools: time since New Moon, observer's current time, current Moon phase, play/pause, and adjusting day/time. Tell students that they will mostly use the play and pause buttons. The buttons below it are used to change time forward or back, and students can adjust it if needed.

Ask students to list three things they notice from the simulation. You can also ask them guiding questions:

- What do you notice?
- What direction does the Moon orbit the Earth?
- Estimate how many days it takes the Moon to orbit the Earth.
- How does it connect to the Moon Tracking handout? When did our Moon observations match what the simulation is showing?

After about 10 to 15 minutes, ask students to try to draw the position of the Sun, Earth, and Moon in their workbook for each Moon observation they have made so far. Tell them they should attempt this *without* using the simulation first. Then, if they want, they can use the simulation to check their work.

Elaborate (30 minutes): Students will use math to predict their next birthday Moon phase

Students will apply their Moon phase understanding from previous activities and math skills to predict their next birthday. The Lunar cycle begins with the New Moon and the cycle is about 28 days or one month. The four main Moon phases are the New Moon, First Quarter Moon, Full Moon, and the Third Quarter Moon. These four main Moon phases change every week, or 7 days. In between the main Moon phases, there is the Waxing Crescent, Waxing Gibbous, Waning Gibbous, and Waning Crescent. There is no set formula for this activity, this will be something students generate on their own-drawing their conclusions and understandings.

Differentiation for younger/older students:

Elementary Students:
Remove the portion of the activity in the workbook that has the students explore the online simulator. Instead, ask students to build a model of the Earth, Sun, and Moon system using styrofoam balls and a flashlight. (See the Explain section of the elementary school lesson for guidance.)

You should also remove the portion of the activity in the workbook that has students calculate the lunar phase on their birthday. Instead, read one of the books from the Elaborate section of the elementary lesson ("Thirteen Moons on a Turtle's Back" or "Taan's Moons: A Hadia Moon Story") and ask the student the following questions:

"Thirteen Moons on Turtle's Back":

- How many Moons did you hear about? What were those Moon names connected to (i.e., seasons, animals, plant changes?
- What do the Native American communities say about the Moon? How is it similar or different to the calendar we use daily?
- From your understanding, what aspects of Moon observation is the story attempting to explain?

"Taan's Moons":

- Taan, the bear, is centered as the main character in the story; how do the different Moons relate to the bear?
- How many Moons do the Haida people have? What were those Moon names connected to (i.e., seasons, other animals, changes to plants)?
- What do you learn about the Haida people's calendar? How is it similar or different to the calendar we use daily? How does place/land play a role in determining different cultures' calendars?

If you have time, you can ask the student to think about what sort of seasonal or important events are happening in their community. They can use their ideas to create their name for the upcoming full Moon. You can extend the activity by having the students make art, a story, or their lunar calendar based on their ideas.

High School Students:
If you are working with high school students and have extra time, you can challenge them to think about and develop models (i.e., 3D models using a sphere or a drawing) to try to understand what Earth phases might look like from the Moon. If you want to direct them, you can have them identify three claims about what Earth phases look like from the Moon that are similar to those about lunar phases.

- The cycle of lunar phases takes 28 days to complete.
- The Moon is waxing (getting more illuminated) when the right side of it is lit.
- The Moon is full when it is on the opposite side of the Earth from the Sun.

Mini-Mission 3: Life in a Closed System

Full Lesson: https://nwessp.org/lesson/artemis-roads-unit-3-lesson-2-life-in-a-closed-system/

Total Estimated Time: 5 hours

Summary: *Students will consider what they think about several different closed systems. Then, students will design and carry out investigations of living things to inform their closed-system models.*

Engage (30 minutes): Students will consider three different closed systems and what might happen in the jars over time.

Display the slide from the resources folder with the three jars. Ask students to consider on their own, then discuss these questions with a partner or small group:

- How are the jars similar? How are they different?
- What is happening inside each jar? Consider flows of energy and matter and the processes taking place. Name or describe as much as you can.
- How would each jar look in 1 hour? Or 1 week? One year?
- What questions do you have about the jars and what is happening inside?

Next, ask students why NASA is interested in closed systems for this Moon mission. Allow students some time to think before sharing with a partner. Then, show Slides 2 and 3. Ask a few students to complete the sentence "NASA is interested in understanding closed systems because….."

Compare/contrast the closed system images on Slides 2 and 3 with the jar idea. How are they similar, and how are they different? Support student discussion around complexity, scale (physical size and numbers of humans and resources), artificial/natural, energy sources, etc.

Explore (180 minutes): Students will design and carry out investigations that will provide data to better understand close systems.

First, watch the first 3 to 4 minutes of this video about Biosphere 2:
https://www.youtube.com/watch?v=-yAcD3wuY2Q

Students will then use the materials available to design their closed system. You may want to provide additional materials, such as rulers or scales, for students to make measurements. They will use this system to address a *testable* science question.

You can prompt them to come up with reasonable ideas for experiments with the following questions:

- What questions do you have about growing plants in a closed system or in space?
- What do you hope your experiment will reveal about life in closed systems?
- How much time do you have?
- What materials are available?

Students should then carefully design their experiment in their workbooks before building their terrarium. Prompts include:

- Identify the science question
- List the materials
- Draw the experimental set-up
- List the steps
- And write an expected outcome

Check the students' plan before allowing them to proceed. If it looks ok, students should build their experiment. Every day they will have time after lunch to tend to their experiment and to make daily observations in their workbook.

Explain (90 minutes): Students will explain the results of their investigation and what new ideas or data they got about life in closed systems.

Have students meet with their groups to ensure that they are all clear about what their experiment showed and how the experiment and any research they did apply to the goal and questions of this lesson.

Then, have each student group present what they learned. If the groups did different complementary experiments, allow students to synthesize the results from the various experiments into one model of a closed system. Students may also want to discuss what went well in the experiment, what went wrong, and how they would improve the experiment if they did it again.

Finally, you can relate this to Biosphere 2, a lunar, or Mars habitat. You can also show students the life support system on the Orion capsule and ask them to relate what they learned to how NASA designs closed systems.

Differentiate for younger students:

Elementary Students:
Younger students can complete the Life in a Closed System experiment, but you may want to limit the supplies provided or give them a short list of variables they can change in their investigation (amount of water, amount of light, type of soil, type of plant, etc.). You can also simplify their experiment by eliminating the need to close the system off in a terrarium (1-liter bottle) and just have them experiment on small plants directly.

Mini-Mission 4: Pack Your Moon Kit

Full Lesson: https://nwessp.org/lesson/artemis-roads-unit-3-lesson-3-thriving-in-space/

Total Estimated Time: 2 hours

Summary: *Students will read about the items that NASA astronauts bring with them to support their overall wellness and then develop a list of items they would bring with them on their own journeys. They will assess what is feasible to bring with them using a series of constraints including personalized criteria for success, size and mass limitations, and any other considerations developed by the class. They will also have an opportunity to consider what their families and communities have brought with them on journeys in relation to the nature of forced or chosen journeys.*

Engage (30 min): Students will consider prompts about which possessions they choose to bring on trips or to class, and why.

Explain to students, "NASA provides everything astronauts NEED to stay alive and do their jobs but astronauts can also bring small personal items to help them stay happy and healthy and fend off boredom, homesickness, etc. NASA astronauts aboard the International Space Station keep a weekly journal, tracking items they use and activities they do regularly to maintain or improve their emotional and mental health. Similarly, we're going to keep journals for one week to track the things that we use to maintain our physical and emotional wellness so that we can incorporate them into our journey."

As a class, in groups, or individually, read the following article: https://www.spacedaily.com/reports/The_Personal_Preference_Kit_What_Astronauts_Take_With_Them_To_Space_999.html

Facilitate student discussion of the following prompts using strategies like think to self, think, pair, share or turn and talk:

- What items did you notice the astronaut(s) brought with them?
- Why do you think they brought this?

Facilitate student discussion of the following prompts using strategies like think to self, think, pair, share or turn and talk:

- Think about a trip you've taken or maybe even what you have with you right now. What is something that you took with you on your trip OR that you have with you right now that is something you WANT, not something you NEED?
- Why didn't you bring every single thing you own with you to camp today? How did you decide what to bring and what to leave at home?
- What things are necessary for staying alive and doing your job (learning), and what did you bring just because?

Explain to students, "We will make an entry in our Daily Log daily to help us think carefully about what makes sense to bring in our personal preference kits or "Moon Kits." Later in the week, we will brainstorm criteria for success, review constraints, and discuss any other considerations we want to use as we monitor the items we may want to bring for our wellness." Show students the template for the journaling in the daily log and model how to complete it.

Explore (60 min): Students will consider what items they might want to take and make initial measurements (size and mass) for potential items.

Lead a discussion with students regarding the following considerations they'll use to decide what to bring to the Moon. Incorporate strategies like think to self, think, pair, share, or turn and talk, as needed:

"**First**, let's think about what each of us considers a good choice of what to bring–this is our criteria for success. Remember that each person will have their criteria for success because every person has different things they will consider important to their wellness on the journey.

Each person, for example, has different things that make them feel happy, connected, or confident. Let's start by thinking about how we want to feel or don't want to feel on our journey. What other emotions might we want to have more of, or less of, while we're on our journey?"

As needed, review a list of emotion words (such as in this emotion wheel) or any emotion charts available in your school's social-emotional learning curriculum.

"Next, let's think about what will fit in our kits. Space and mass will be limited on our journey to the Moon, so we'll need to measure what we want to bring to see if it fits or if it's too heavy. For example, can we bring our pet elephant? Why not?"

Tell students what size and mass constraints they will be using.

- Each student's Personal Preference Kit (PPK) has the same size and weight restrictions as NASA astronauts traveling to the international space station!
    - A maximum of 10 items
    - Must fit in a 5" X 8" X 2" (12.7 cm X 20.32 cm X 5.08 cm) bag or container
    - Maximum weight limit of 3.3 lbs (1.5 kg)

Model for students how to take measurements of everyday objects (length, width, and height) to estimate volume, as well as how to estimate mass using a scale or by comparing to the mass of everyday objects. If students don't have access to a scale, here is a chart with mass approximations that can be used.

"Last, let's think about any other considerations we want to use to guide us while we think through items to bring for our wellness. For example, can we bring fireworks if fireworks always make us happy and it would fit in our kit? Why not? What other things might we want to consider?"

If students have trouble coming up with ideas, consider asking probing questions, such as:

- Is it safe to bring to space?
- If you are in space for two months, will your item be OK?
- What will your crewmates think about your item?

Explain (30 min): Students will decide on and document their kits, then share their plans with others.

Now that students have recorded the personal items they would like to bring on their journey, they will use their measurements from the week to plan their Personal Preference Kits.

In small groups, have students check their peers' work against the class considerations developed in Explore (criteria for success, size and mass constraints, and any additional considerations set by the class). For example, students can take turns in their small groups explaining the criteria for success they used and explain how their kit helps them meet them. Allow students to give one another feedback that can be incorporated into any revisions.

To support students in assessing and visualizing what will fit in their kits, you can make a physical model of the size of the kit to test their items against and/or a scale 3-D drawing. For example, each student's Personal Preference Kit (PPK) must fit in a 5" X 8" X 2" (12.7 cm X 20.32 cm X 5.08 cm) bag. You can make a physical model of the PPK bag using cardboard or construction paper, and/or you can create a scale drawing of the bag on paper.

Mini-Mission 5: Investigate the Moon's Surface

Full Lesson: https://nwessp.org/lesson/artemis-roads-unit-2-lesson-1-the-moons-surface/

Summary: *Students will examine the surface of the Moon to consider hazardous conditions that NASA may find there. Then, they will investigate several hazards (dust, boulders, and slopes) and predict what kinds of wheels might be best to address these hazards.*

Total Estimated Time: 1.5 hours

Engage (45 min): Students will examine the Moon's surface, describe what they see, and begin compiling a question list about the Moon's surface and the conditions they will need to prepare for.

You have several options for the Engage portion of the lesson. Decide which resources below to use, then show your chosen options or allow students to explore. Direct students to create a word list that describes what they see on the surface of the Moon.

- Basic Option (Still images): Allow students to view or explore the slides for the ENGAGE portion of the lesson in the resources folder.
- Basic Option (Video): Watch this video with the SOUND OFF, starting at 39 seconds: https://www.youtube.com/watch?v=XFjkVBpMkDs&t=39s
- Basic Option (Video): There is no sound on this video of the Apollo 16 rover. https://www.youtube.com/watch?v=AXAmsaxoehs
- Intermediate Option: Video (no sound) of Shackleton Crater https://www.youtube.com/watch?v=p1OIDCXd2v8
- Intermediate Option: Explore still images from NASA's Apollo 17 mission https://moon.nasa.gov/news/107/nasa-releases-stunning-panoramas-of-apollo-landing-sites-for-50th-anniversary/ AND https://flic.kr/s/aHsjHYKZe3 AND https://go.nasa.gov/2YXLtbh
- Advanced Option: NASA Moon Trek. We recommend ensuring students work through Moon Trek's tutorial before beginning. **https://trek.nasa.gov/moon/**

Have students add words to a class word cloud (using something like Mentimeter) or a class word list. When you have compiled a list, refer back to the list and ask students which features on the Moon's surface might be dangerous to people or Moon rovers and why. Give them a chance to discuss with a partner or in a small group, then take ideas. The sentence frames below might be helpful.

_______ could be dangerous on the Moon because _______
_______ could cause problems for a person or rover because _______

It is likely that students will come up with several ideas, but we are hoping "Moon dust" and steep slopes are two of them. If students don't bring these up as potential problems, allow students to consider why each might be a problem for people or rovers.

Explore (45 min): Students will explore how NASA develops strategies to deal with the challenges listed above.

In small groups, give students access to the following NASA resources. You can assign them to student teams or pairs of students. The goal is to learn how NASA designs rovers to help mitigate the challenges. Have students write their ideas in their workbooks and consider having them share out at the end of the activity.

- Scroll down to explore this interactive video about the wheels on other Moon rovers https://www.nasa.gov/specials/wheels/. Don't miss the videos!
- This interactive allows you to explore the NASA SLOPE Lab, where past and current rover wheel testing is done. https://www.nasa.gov/specials/slope360/   In the upper left, choose "SLOPE: Lab" or "SLOPE: Rover Tires" to explore.
- An article about VIPER, the upcoming Moon Rover, being tested in SLOPE lab. https://www.nasa.gov/feature/glenn/2021/viper-hits-the-slopes

Mini-Mission 6: Rover Development and Surface Navigation

Full Lesson from Artemis ROAD Companion Course (Team Challenge 2):
https://nwessp.org/lesson/artemis-roads-unit-4-lesson-3-rover/

Full Lesson from Artemis ROAD II Companion Course (Team Challenge 3):
https://nwessp.org/lesson/artemis-roads-ii-unit-3-lesson-4-rov-ing-on-the-moon/

Full Lesson from Artemis ROAD III Companion Course (Team Challenge 4):
https://nwessp.org/lesson/artemis-iii-5/

Summary: *This activity guides students through building, programming, and testing a Lego-based rover to complete various lunar-inspired challenges. Students first learn basic programming and sensor use, then apply these skills to increasingly complex tasks, such as designing a rover that can travel up steep slopes using the engineering design process, programming a rover to sense the colors of packages and deliver them to specific destinations, and programming a rover to navigate a lunar lava tube. By the end, students will have developed problem-solving, teamwork, and coding skills while exploring real-world robotics applications in space exploration.*

Estimated Time: Up to 11 hours, depending on how many activities you complete

Before the mission:

- Download to Software:
  Lego SPIKE: SPIKE Prime | Student App Download | Lego® Education
  Lego Mindstorm EV3: MINDSTORMS EV3 downloads – Lego Education
- Go through the Tutorial by clicking on "Start" tab at the top of the window and then "Teacher Preparations"
- Go through each of the "Getting Started" modules to familiarize yourself with the robot and basic programming
- Prepare the kits (if necessary) by adding stickers to the included drawers that show students how to sort the blocks.
- Make sure the robots are fully charged.
- Provide each team with one robot kit.

We recommend you start by having the students build the following rovers:

- *Lego MindStorm EV3 Instructions:* Have the students click on the "Build" tab at the top of the window and direct them to build the robot called "Driving Base."
- *Lego SPIKE Instructions:* Have the students click on the "Build" tab at the top of the window and direct them to build the robot called "Driving Base 1."

These are good first builds that can be modified to fit the challenge. Students can explore other instructions under the "Build" tab for additional ideas on how to modify their robot. The students can modify the rover as much as they like, and they are not required only to use Lego pieces in their design.

Explore (120 min): In the first session, students will build their rover and use Lego resources to learn how to program it.

Split students up into small groups. It is best to have only two students per robot for this initial lesson to make sure each student gets a chance to learn. Given the limited number of robots, you may have to allow larger groups or rotate students doing this activity with another activity, like building the ramp to use in the Engage portion of this mini-mission.

Have students build the robot using the directions provided in the Lego app. Once it is built, ask them to go through the "Training Camp 1: Driving Around" lesson in the Competition Ready Unit. If they have more time, they can continue with the other training activities in that same unit.

Finally, ask them to fill out the portion of the student workbook that shows blocks of code. You may wish to sit down with each group or project these blocks of code to the whole class to ensure each student understands what they do.

CHARGE ROBOT: After using the robots, charge the robots' hubs for the next lesson.

Team Challenge 1 (90-120 min): In the second portion of the Explore, students will program their robot to follow the path in the provided Artemis ROADS practice map.

Split students up into their teams. Show the students the Artemis ROADS practice map. Tell them they must write the steps they would like the robot to follow *before* programming their robot. This is what is known as pseudo-code.

Show the slides from the resource folder (or write out or print) to show an example of a pseudo-code that describes the steps for making a peanut butter and jelly sandwich. Ask the students to write pseudo code for another everyday task or for the steps needed to walk across the room, open the door, or throw out some paper.

Give the students the Artemis ROADS practice maps (small map with yellow line, 1 per group) and have them write out the pseudo-code for following the yellow line *before* you give them access to the computer to program their robot. Once a group is done, give them their computer and ask them to translate their steps to code. They can test their code using the practice map taped to the floor.

At the end of this activity, you can prompt a discussion about why pseudo code or thinking about the steps you want to program *before* diving into the code is helpful.

CHARGE EACH ROBOT: Don't forget to plug the robot into the charger after each session!

Team Challenge 2 (~120-150 min): Students will use the Engineering Design Process to create and iteratively test the mechanical design of a robot to go up steep surfaces.

Tell students they will watch a video of rover test environments in the Mars Yard. Ask students to pay close attention to the slopes and then ask, “What do you notice?” Play video. As a whole class, have students discuss the test environment slopes in Mars Yard and SLOPE lab.

PLAN (20 Min): *Students will brainstorm and sketch possible design changes to the standard robot they designed to increase its ability to drive up steep slopes.*

Tell groups that they will build a ramp adjustable in steepness to test their rover’s climbing ability to drive up and down the slope. Tell students to sketch or list two or three best ideas about improving their rover’s ability to drive up this ramp on their Engineering Design Process (EDP) worksheet in their workbook. Then tell students to discuss their ideas with their teammates and choose the idea(s) they want to build and test.

CREATE (50 Min): *Students will build a prototype of their rover to test out on a ramp.*

Give students materials for building adjustable ramps for traversing the range of slopes. We recommend a ramp that is about 18” long and 12” wide ramp

Students should also create the prototype design based on the ideas they chose at the end of their planning session. Teams may choose to adjust the wheel design, the number of wheels, its size/shape, or how the mass is distributed. You may allow students to incorporate alternative materials in their design (like tape, extra masses, cardboard), but please do not permanently alter the rover provided by NESSP.

TEST/IMPROVE/CREATE/TEST CYCLE (40 Min): *Students will evaluate their rover designs using the Engineering Design Process.*

Students should test the prototype rovers they created on their ramp. Based on the results of the test, they should identify new problems and solutions and design new prototypes. Each time they change their rover and perform a new test, they should document their results in their workbook. You may also ask students to take pictures of their rover so they can better describe their process in the final presentations at the end of the week.

CHARGE EACH ROBOT: Don’t forget to plug the robot into the charger after each session!

Team Challenge 3 (120 min): Students will modify and program their robot to deliver different colored packages to colored targets placed on a challenge map that they design.

For this team challenge, students will complete a challenge similar to the ROV-ing on the Moon mission objective in the Artemis ROADS II Challenge. Students should work in groups of 3 to 6 (depending on space on the number of robots available).

Students will need to understand how to use the color sensor and use If-else control blocks in their programs. The "Using the Color Sensor and If-then Control Blocks" in the slides in the resource folder can be used to introduce these concepts to the students before they take on the following challenge.

You can show the slide with the labeled Artemis ROADS II Final Challenge Map from the slides in the resource folder. Tell students that the goal is to deliver samples from the start area near the Main Habitat to the colored target areas and that the natural and man-made hazards shown in magenta. Instead of following this exact map, the students can use print outs of these hazards and obstacles to design their own challenge map. The packages will be loaded into a "payload bay" on the rover. The "payload bay" can be a holding area, a grabber, or a pusher; depending on whether you want students to drop off the samples at the target or simply drive to the target. Once inside the payload bay, the rover will detect the color of the payload using the color sensor. This color will determine the station that the payload will be delivered to:

- red packages must be taken to the Observatory,
- green packages are sent to the Earth Communication Outpost,
- yellow packages to the Launch Complex, and
- blue packages to the Crater Ice Research Station.

After driving to that location, the rover should return to the start position near the main habitat and wait for another payload to be placed in its payload bay. (*Note: If you choose, you can ask the student to include a mechanism to drop off the sample as close to the center of the target as possible before returning to the start position to receive another sample.*)

Instruct them to take approximately 5 minutes to discuss their approach to the challenge. Emphasize that since it is a significant challenge, it is helpful to break it down into smaller, achievable steps. Encourage them to brainstorm and discuss how they can divide the challenge into manageable pieces.

Gather ideas from the class. You should generate a list of steps that is similar to:

- Determine the path the rover will take between the main habitat and each of the stations.
- Measure distance of straight paths the rover needs to drive and the angles the rover needs to turn.
- Write the steps (pseudo code) for the rover.
- Program the rover to drive to each of the stations.
- Build a payload bay on the rover with a color sensor.
- Program the rover so that it drives one of the paths depending on what color is sensed.

After creating a list, prompt the students to identify the most sensible sequence in which these instructions should be carried out.

Next, tell the groups that it is time to execute their plan and distribute the printed targets and obstacles so students can build their own lunar station map (you can also look at Artemis ROADS II Final Rover Challenge Map for guidance on printing or making a map).

While the students are working, walk around the class and monitor the groups to make sure they are working as a team and following their plan. The teams will run into many challenges along the way. If that happens, sit down with the team and ask them to look at their plan. Have them tell you what portion they are struggling to accomplish. If it is a coding problem, the students may need to scale back and make sure they are programming and testing small blocks of code at a time. Make sure students are referring to the pseudo code they write as a guide to what they should be programming.

CHARGE EACH ROBOT: Don't forget to plug the robot into the charger after each session!

Team Challenge 4 (180 min): Students will investigate how to use ultrasonic distance sensors to program a robot to travel autonomously through a lunar lava tube (tunnel with 90 degree corners). Students will build a flexible lava tube course and use it to test their robot.

(Optional) Watch: Lava Tubes: Science Beneath the Surface of the Moon

Tell the students, "Your next challenge will be to program a rover that will use its sensors and measurement tools to explore and map a lunar lava tube all on its own."

Show students the "Lava Tube Map" in the slides in the resource folder. Explain that their rover must sense where the walls and openings of the tube are to drive through it without any input from the driver.

To do this, students must first determine which of the Lego sensors will be most useful for determining where the walls and openings of the tunnel are. Show them the sensor slides and go through each sensor. Students should choose the ultrasonic distance sensor, although some may be tempted to use the force sensor, which can detect if the robot physically bumps into the wall, but that isn't how you would want your autonomous vehicle to navigate the streets.

Ask the students to add the ultrasonic distance sensor to their robot. They should be free to add it however they choose. They can make adjustments later during the testing phase.

Next ask them to adjust their robots and write a program so that their robot:

- Automatically stops when it encounters a wall
- Makes a right turn when it encounters a corner that leads right (see slides and video for guidance)
- Makes a left turn when it encounters a corner that leads left (see slides and video for guidance)

There are short video examples of this type of motion in the slides.

Students should then construct lava tube paths with different twists and turns to test their rover (see the Artemis ROADS III Challenge Map for some example paths). The team should start with shorter segments at first. If you have a large class, you may choose to give each group just a couple of tube segments and corners initially. A successfully programmed robot should be able to navigate any configuration on its own.

Educators will now evaluate each group's rover by configuring the course using most or all of the tube segments and corners constructed by the class. The course can be similar to one of the examples shown for the Artemis ROADS III Challenge Course, or they could be an original invention. Each group will then be asked to send their rover through the course to see if it can navigate it and find its way out.

CHARGE EACH ROBOT: Don’t forget to plug the robot into the charger after each session!

Mini-Mission 7: Craters

Full Lesson: https://nwessp.org/lesson/artemis-roads-unit-2-lesson-2-craters/

Summary: *Students will start by examining the Moon's surface and wondering about the craters they see. Then, they will engage in hands-on activities to discover factors that affect crater formation and crater slopes. Finally, they will use the craters they create to try and capture images that look the same as real craters on the Moon using shadows and light and then document their learning from the lesson.*

Estimated Time: 90 minutes

Engage (10 minutes): Students will speculate on reasons behind the sizes, shapes, and distribution of craters on the Moon.

Go to https://science.nasa.gov/moon/composition/ and display the website for students (or give students access to the website)

- Click on "Data" in the bar menu on the right in the interactive graphic with the Moon

In the drop-down menu at the left, "Digital Elevation model" should be selected. This allows you to see the craters on the Moon more clearly.

Rotate the Moon by clicking and dragging. Ask students:

- What do you notice, and what do you wonder about the size, shape, and distribution of craters on the Moon?
- How similar or different are the craters, from what you can see here?
- Do you notice any patterns?

Allow students time to think independently and share with a partner before sharing in a larger group or the whole class.

Explore (40 min): Students will design and carry out investigations on the variables that affect the size and shape of impact craters and the steepness of crater slopes.

Ask students to discuss what variables they think might be important. If the class list does not include the following critical ideas, ask probing questions to lead students to these ideas.

- Mass, size, and speed of the object that hits Earth
- The angle that the object hits the ground
- The type of material the ground is made of

Have each group of students choose one variable that they can carefully test. Students should then design an investigation where they adjust this variable and document their results (maybe with a drawing or photo). They can also take measurements such as the diameter and depth of the crater. Students should document their experiments in their workbooks.

Explain (40 min): Students will use light sources and craters they made to recreate crater images from the Moon's surface.

The shape and size of the crater aren't the only factors that influence how craters look on the

Moon. Students will use a flashlight and the crater “laboratory” to try to recreate images of Moon craters. Darken the classroom (or give students large cardboard boxes with viewing and light ports cut into the sides so they can view and light their craters from various angles). Allow students to set up and take images that match the craters shown as closely as possible. Make sure that students record information such as where the light was coming from compared to the camera for their recreated images.

Mini-Mission 8: Getting to the Moon

Full Lesson from Artemis ROADS II Companion Course:
https://nwessp.org/lesson/artemis-roads-ii-unit-2-lesson-2-getting-to-the-moon/

Full Lesson from Artemis ROADS III Companion Course:
https://nwessp.org/lesson/artemis-iii-6/

Summary: Students will first learn why tests are important in the Engineering Design Process by learning about the various tests that NASA conducted before the Artemis I mission. Next students will complete a set of two hands-on activities to learn about concepts that are relevant to rocket flight. Finally, students will use the Engineering Design Process to improve on their own water bottle rocket design. Students will be asked to build several designs (changing a single variable) and then analyze flight data to determine the most successful design. To take this further, you can also challenge students to add a “crew capsule” to their rocket and test whether it can keep a “chipstronaut” or other fragile device safe during launch.

Estimated Time: 6 hours

Engage (20 minutes): Students will discuss how they have learned a new activity or improved their ability to do an activity through an iterative process. Then they will relate this to the process that NASA used to test the SLS rocket before, during, and after its successful Artemis I mission.

Ask the students, “List 3 to 4 tasks or activities you do often, it could be a sport, a hobby, or an activity at school.”

Now ask the students, “Pick an activity that you do well now, but did not go very well the very first time you tried it. How did it go? Does anyone want to tell a story or give an example?”

Next, ask the students, “How did you get better at that activity? Did you repeat the activity or, perhaps, change the way you did it to improve the outcome?”

Solicit a few examples from the students. A good example might be learning to bake cookies or a cake. In that case, the recipe or how the steps were followed might have needed to be adjusted to get better results. For a sport, students might have practiced the activity over and over again until they had internalized the needed movement or memorized the plays used by their team.

Finally, ask students, “How do you think your experience of getting better at your activity over time or through repetition is similar to the process that NASA might use to build a successful and safe rocket like the Artemis Space Launch System or SLS?”

Show the slide labeled “Space Launch System (SLS) Rocket” with the part of the Space Launch System (SLS) Rocket and give a brief description of what each part does. Say, “The Space

Launch System known as the SLS is the rocket designed to take humans back to the Moon. It has several important components. It has four RS-25 engines that are designed to provide 2 millions pounds of thrust during launch. The Core Stage is a 212-foot tall tank that holds 733,000 gallons of propellant for the four RS-25 engines. All of that propellant is used up within the first 8 minutes of launch. The two Solid Rocket Boosters are each 17 stories tall. They provide 3.6 million pounds of thrust in the first two minutes of flight. The Orion Spacecraft is designed to carry 4 astronauts to the Moon and back, landing safely with parachutes in the ocean. The Upper Stage holds the propellant for the Orion spacecraft to use in the final push to get the Orion Spacecraft to the Moon."

This video describes the importance of testing and some of the test that NASA SLS needed to undergo before flight: No Small Steps Episode 5: Passing the Test

Tell students that, "Artemis I was the final test of the SLS rocket, the Orion space capsule, and other life support systems. NASA is carefully analyzing data from the flight to determine whether changes need to be made to their designs to make future missions like Artemis II safer and as successful as possible, especially since astronauts will be on board. In this activity, you will learn how to test and design your own rockets made with water bottles. Since these rockets are a little easier to launch than the SLS you can test your rocket over several launches and improve on its design. But, first, you need to explore some of the important physics principles that go into designing a successful rocket."

Explore (40 min): Students will complete two hands-on activities to discover the physical science concepts that are relevant to designing a successful model rocket: center of mass and center of pressure.

Groups of students will complete two hands-on activities to understand the physics of rocket flight. If time is a constraint, the group can be split and groups of students can complete only one of these activities but share what they learned with the rest of the class. Students can also keep track of their work and observations in their Student Mission Development Log.

Activity 1: Center of mass and rotation activity (20 min depending):
In the first activity, students will use a straight wooden dowel (¼" or ½" x 10") and clay to investigate the center of mass and how it affects the rotation of the object. The questions they will answer include:

- How do you find the center of mass of an object?
- What do you notice about the relationship between the center of mass and how an object rotates through space?
- Why might a rocket start to rotate during its flight?
- Where do you think the center of mass is on most rockets? Is it near the center of the rocket, near the top of the rocket, or near the bottom? Why do you think that is?
- What can NASA do to determine what point a rocket will rotate around during flight?

To complete this activity students will be asked to find the center of mass of their wooden dowel by balancing it on their finger, at the edge of a table, or with a string. The slide from the resource folder can be displayed to guide the students. Students should then "label" this point using a brightly colored marker or by tying a piece of brightly colored string or a rubber band around it.

Next students will safely toss the dowel in the air and observe how it rotates. Students should notice it rotates around the center of mass. If students have phones or cameras, they can record the rotation in slow motion to make this phenomenon more clear. The Explore slides include an example of a slow motion recording.

Next, students should change the location of the center of mass by adding clumps of clay at various locations along the dowel (see the “Adjust the Center of Mass” slide from the resource folder), balance the dowel to find the center of mass again, label it, and then observe its rotation. Students can do this several times, keeping track of their observations with the Center of Mass Worksheet or by taking notes on paper or in a lab notebook.

Activity 2: Center of pressure, stability, and fins (30 min):
In the second activity, students will use a straight wooden dowel (¼” or ½” x 10”) and cardboard to investigate the concept of center of pressure and how fins add stability to a rocket's flight. The questions they will answer include:

- What determines the center of pressure of a rocket?
- What happens when the center of pressure is ahead of the string? What happens when the center of pressure is behind the string?
- How do fins affect the flight of a rocket? Do you think the size of fins matter? Why or why not?
- Where should fins be attached to the rocket and why?
- Rockets like NASA’s Space Launch System don't have big fins, what does it do to maintain a stable flight instead?

To complete this activity students will cut out 4 fins from the cardboard. They can start with the provided “Fin guide for center of pressure activity” slide from the resource folder or design their own (of a similar size). Next they will attach the fins to the wooden dowel. The fins should be equally spaced (90 degrees apart). An example of what a “stick rocket” can look like is shown on slide “Build your stick rocket!”.

Students should then tie the string around the dowel at the point where the rocket is balanced when suspended only by the string. They can find this point through trial and error. Once this point is found, students should then safely spin the rocket over their heads, observing how it flies through the air. Students should note whether the flight is stable or unstable. A video demonstrating this motion is included in the Explore slides. Note, students can also test their rocket by “taking it for a walk”. In this case, they hang the rocket by the string and briskly walk forward and observe how the rocket travels through the air.

Finally, students will find or estimate the location of the center of pressure. If you choose to have the student “find” the center of pressure see details for how to do this for grade bands below. The grade-level appropriate “Find the Center of Pressure” or “Calculate the Center of Pressure” slides from the resource folder can be displayed to guide the students.

Upper Elementary: Students in upper elementary school can use a graph paper to determine the center of pressure. Students should trace the vertical cross-sectional area of their dowel and fins on the graph paper. Students can then count the number of grid boxes inside the traced outline. The location of the center of pressure (in the vertical direction) will be the point where there is the same number of grid boxes above and below. The slides provide an example to demonstrate this technique to the students.

Middle School/High School: Students in middle school can draw an outline of their dowel plus fins similar to the upper elementary. However, they should then use shapes and known formulas for the area of shapes to determine the total vertical cross sectional area. They can use the area they calculated to determine the point along the dowel where half the area is above and below. This works best if the fins have straightforward shapes like rectangles, parallelograms, triangles, or half-circles.

Explain (120 min): Students will use what they learned about the physics of rocket flight during the Explore portion to design and construct an initial water bottle rocket.

Put students in groups of 3 to 6 students. Each group will then be asked to design and construct their own water bottle rocket design.

First tell students, "You will be designing a water bottle rocket. The goal is to create a rocket that can fly as high as possible with a nice stable, straight flight." Based on this information, ask students to write a sentence or two to describe their objective in the "Ask" portion of the Engineering Design Process in the student workbook.

Show students each of the materials that will be provided to them for the design of their rocket. This should include:

- Empty and clean 2-liter soda or water bottles
- Duct or packing tape
- Sturdy cardboard or balsa wood
- Tape (clear packing tape or duct tape is preferable)
- Glue (hot or quick drying gel glue is preferable)
- Scissors and/or box cutters
- Rulers

Depending on the age of the students and the resources available, you may choose to offer additional supplies. However, materials should not be preconstructed (like commercially available fins) because students will need to be able to adjust aspects of their rocket design in the next step.

Before students build their first rocket design they should discuss the following with their group:

- What shape do we want the nose cone to be?
- What shape of fins do we want to use?
- How many fins do we want?
- What materials do we want to use?
- How do we plan to attach our fins and nose cone to our rockets?

Students should add their ideas to the "Imagine" box of the Engineering Design Process handout in the student workbook. You may want to give students white boards or blank sheets of paper so they can sketch their ideas to share with their group.

After this discussion, ask students to settle on a final initial design. Tell students to sketch this design, labeling parts and what materials they will be constructed with, in “Plan 2” of their Engineering Design Process handout.

Students should then be given time to build their individual rocket using the supplies provided. The instructor should walk around the room to monitor the students' work, making sure they are following their plan and stay on task. Students may need up to 40 minutes to complete their first rocket.

Before launching the rocket, hold a discussion with the group of students regarding how they will assess their rocket design. Say, “We need to be able to evaluate how good the design of each rocket is. What are your ideas about how we can evaluate each design?”

After generating a list, ask the students, “What factors other than your rocket design might affect their flight?” They may bring up factors like wind or differences in how much air or water is added to the rocket during launch. You should have a discussion about how to best control for any variables you can.

Review the “Water Bottle Rocket Safety Guidelines” slide before launching the rocket.

If you would like students to measure the altitude of their rockets you should show students how to use the Estes altitude trackers before the first launch. You can also use a digital Estes altimeter (not provided by NESSP) or launch at an angle and judge the designs by the horizontal distance traveled.

Students should then come up with a plan for what they will observe and note during the launch. They should sketch their plans on the Test portion of their Engineering Design Process Worksheet.

Next, students and the instructor should go outside and launch each group’s rocket.

Launch instructions for the Aquapod Launchers (see individual instructions for other kits):

1. *Fill the Bottle:* Pour water into the 2-liter soda bottle until it's about one-third full.
2. *Lubricate the nozzle:* Use grease or lubricant on the launching valve. This is not provided in the kit but it's really helpful. The rocket might have a hard time launching without it.
3. *Load the rocket:* Flip the launcher upside-down to load the rocket. Make sure the rocket is fully secured by the latch.
4. *Secure the launcher:* Use pins or tent poles to secure the launcher to the ground. This makes sure it does not fall over (causing the rocket to launch sideways) before flight.
5. *Pressurize:* Use a bicycle pump with a pressure gauge to pressurize the rocket. The Aquapod instructions say it can handle up to 50 psi (pounds per square inch) of pressure, but they also have a safety pressure release value that can, on some units, limit the pressure at 40 psi. For the rocket to work well, it needs to have at least 40 psi of pressure.
6. *Safety check:* Make sure everyone is paying attention and is a safe distance from the launcher. Check for overhead obstructions.
7. *3-2-1 Launch:* Move as far away from the rocket as possible and have you or a student count down and pull the string to research the rocket.

Elaborate (120 min): Students will use the Engineering Design Process to adjust their design while also taking careful measurements during flight to evaluate how their changes to the rocket's design affected its flight

Students will then return to the classroom and determine one aspect of their design they can change in an attempt to improve the maximum altitude of their rocket and the stability of their rocket flight.

Tell them, "You can change only one aspect of your initial design each time we relaunch your water bottle rocket. For example, you may choose to change the mass of your rocket, the area of its fins, the location of its fins, or the length of your rocket. Discuss the results of your first flight with your group and decide as a team what aspect you would like to change."

You may choose to allow students to build a new rocket with another 2-liter bottle or have them remove/adjust pieces of their first design. Either way, it should be made clear to each group that they should only change one aspect of their design. The design aspect they chose to adjust should be carefully documented by making a new drawing in the "Plan 2" portion of their Engineering Design Process handout.

After adjusting their rockets, students should go outside and relaunch. Again each rocket should be filled with the same amount of water and be pumped to the same amount of pressure. If possible, each design should be launched two to three times.

If time allows, students will then return to the classroom to adjust the ***same*** aspect of their design one more time. For example, if they changed the size or shape of the rocket's fins, they should change the size and shape of the fins again, rather than changing the length of the rocket. Again, make it clear to students that they must keep all other aspects of their design the same.

Students will then go outside and relaunch their rockets one final time. Again each rocket should be filled with the same amount of water and be pumped to the same amount of pressure. If possible, each design should be launched two to three times.

Evaluate (20 min): Students will analyze the test using the test data from their flights to determine the most effective design of their rocket.

Students will analyze the test using the test data from their flights to determine the most effective design of their rocket. The conclusions they draw can be described in the Share portion of the Engineering Design Process Worksheet.

Mini-Mission 9: Build a Habitat

Full Lesson from Artemis ROADS II Companion Course:
https://nwessp.org/lesson/artemis-roads-ii-unit-3-lesson-1-building-habitats-on-the-moon/

Summary: *Students will start by considering how and why structures on Earth are built, and then consider the needs of astronauts living and working on the Moon. They will experiment with simulated Moon regolith as a building material, then design and build a scale model of a habitat to meet the astronauts' needs. Finally, they will document what they did in this lesson.*

Estimated Time: 5.5 hours

Engage (30 mins): Students will compare and contrast various structures used for human habitation from a materials and purpose standpoint.

	Consider adding photos of locally or culturally relevant building styles from your area to the slide deck for this part of the lesson. If you teach older students, consider allowing them to research different structures from parts of the world that interest them. You might find this Padlet of locally and culturally relevant habitats helpful.

Say: You might know the word "habitat" from biology class. Scientists use this word to describe where animals live. However, NASA also uses the word "habitat" to describe the structures where astronauts will live and work on the Moon, and eventually on Mars.

First, look at the images in the slide set from the resource folder. Display the images or give students view-only access to the file. Ask students to choose two different habitats and compare/contrast them. It is up to you if students do this individually or with a partner. Thinking prompts are on the first slide.

If students worked alone, pair them up to discuss their ideas about the prompts with a partner. If they worked with a partner, make a group of 4 so that they can discuss. Then, bring the whole class together to highlight a few key points, including:

- Which structures use inexpensive, locally available materials? (Students might say: Teepee, adobe house, igloo, stilt house, cave)
- Which structures protect people from extreme environments or hazards? (Students might say: Igloo (cold), adobe (heat), Space station (space!), stilt house (floods)

In this lesson, we are going to consider what needs our Moon habitat must meet, what materials we are going to use to build it, and how we might design, build, and test a scale model.

Explore (120 Min): *Students will explore two articles about how NASA designs, builds, and tests scale model habitats and then test the properties of regolith as a building material.*

Grade Level Adaptation	There are two articles for students to read in this part of the lesson. Each article is available in multiple reading levels. Preview the articles to choose the reading level that works best for your student. We recommend that you remove the grade level title when copying the article for your students. Article 1: A2 U3 L1 Explore Reading, Base Camp Article 1 (Spanish Version): A2 U3 L1 Campamento base, lectura exploratoria Presentation Link Article 2: A2 U3 L1 Explore Reading, 3D printing Article 2 (Spanish Version): A2 U3 L1 Lectura exploratoria, Impresión en 3D Presentation Link

Say: The first thing we need to consider is the goals we want to meet and the things that astronauts and NASA want and need from the habitat. These are called "Criteria." One criteria is that the habitat has to work for four astronauts for one month. Some criteria are more important than others, like keeping the astronauts alive. But there are a lot of other goals. For example, what kinds of spaces our astronauts will need for their base camp habitat? What work must the astronauts complete on the Moon and how does this impact the design of the habitat?

Take student ideas. Read this article (Article 1) and consider what needs (Criteria) our astronauts will have and what they might like to have in their habitat.

Give students your chosen version of Article 1. Allow them to read individually or in partners, and encourage them to keep a list of what the astronauts will need or want.

Go over the criteria list as a whole class. Make sure that students understand that they will need to have a space for four astronauts to live and work for one month. List all of the kinds of spaces needed. Make sure they have mentioned sleeping quarters, food storage and preparation, bathroom, working areas, exercise area, and some kind of air lock where they can change into and out of their space suits. Decide as a class which Criteria are required ("must haves") and which are less important or optional ("would be nice to haves").

Then, give students access to your chosen version of Article 2. This article talks about two university teams who are competing to make the best Moon habitat using soil found on the Moon. Allow students to read individually or in partners, and encourage them to consider how we could build and test a scale model habitat in the classroom as they read.

After students read the article the first time, ask them to look back to answer these prompts:

- What were the scale model habitats made of?
- How big were these scale models? (Answer: ⅓ scale)
- What kinds of tests were done on the habitat models? (air tightness, strength)

Local and Cultural Relevance	The following document has three examples of locally and culturally relevant building techniques and materials from the Pacific Northwest. At the end of the document we have listed various examples. Feel free to add examples that are relevant for your area. Take a look at this Padlet. You can ask your students to read the document using the jigsaw method. Students should then answer the reflection questions at the end. A2 U3L1 Building Techniques & Materials Spanish Version: A2 U3L1 Técnicas y materiales de contrucción

Then, show the sample of “Moon dust” or regolith. Point out that this is not real Moon regolith, but rather Earth materials that are as similar to Moon dust as possible. Ask students what they should do to figure out how to build a habitat with material like this.

Regolith Testing
For this part of the lesson, you may use the sample of simulated Moon regolith (available from NESSP) or regolith-like materials such as fine sand, flour, etc. You may wish to have several kinds of sand (very fine to coarse) and allow students to mix them together. You may also wish to provide various things that students can mix with the regolith or regolith-like materials to make a paste that they can “3D print” using the pastry bags. This could include just water, white glue, corn starch, or other items. It is also a good idea to have your students document this process with writing (recipes), photos, and/or videos as the work progresses.

Say: One way to build a habitat in a new place is to use what you find there as your building material. What is available on the Moon for building? Dust! Moon dust is called “regolith” and it is made of tiny, sharp particles because there is no weathering on the Moon. In this part of the lesson, we will explore what it might be like to use regolith as a building material.

Working with the Regolith video
Watch the video clip--what do students notice and wonder about the material that is being “printed” here? How might we make samples of this material to find out the best recipe, see how it dries, and measure its strength?

The first step is to plan--both what students plan to mix, and what we are going to observe or measure about our samples. Lead a planning discussion for their recipes, which can start by showing them the ingredients that are available and asking them to consider which materials might work best.

Before students start mixing, lead a conversation about testing. Ask students what they might observe or measure about their samples in order to know which mix is best? This might involve looking back at conditions on the Moon or astronaut needs. If students are struggling to imagine tests, consider the information in the following table. EITHER mention the first column (what we observe or measure) and ask students to explain what question that measurement would answer OR mention the second column (question) and ask them what they would observe or measure to answer that question.

Once students have an idea of their recipe and their tests, each team should make and test at least two different mixture “recipes” so that they can compare their results. If you have multiple teams, they can all make their own unique recipe, which will allow the whole class to compare results of a wider range of recipes. Be sure that you have them track their ingredients and which mix is which! Students should carefully measure and record the amount of each ingredient that is added to the mix.

Students can make simple “worm” shapes or make a small “wall” section by building up layers of their material. Be sure students label which sample was made with which mix! Make sure they make any necessary measurements (size, mass, etc) before drying! It is likely that these samples will need to dry overnight before they can be subjected to your students’ testing plan.

When the samples are set, students should observe and measure the results of their chosen testing plan and track how each recipe performs.

At the conclusion of testing, have all groups share their recipes and which one worked better, according to their measurements and tests. What conclusions can you draw as a class about the best recipe? Discuss! Make sure students capture their recipes and testing results (as well as photos) before moving on.

Explain (90 Min): *Students will create design plans for their habitats.*

Next, students will plan their Moon habitats. In planning a project like this, it can be useful to understand how engineers represent their work. Use the “Explain” slide deck to demonstrate several different ways that engineers convey their ideas. Tell students that they will make both concept drawings and design drawings as part of their planning process.

If your students lack prior experience with floor plans, consider trying Option 1 from the Extend part of the lesson (scroll down in this file).

It is now time for students to plan their habitats! Give students graph paper (or use the guide in the Student Development Log) to draw out their scale models.

Make sure to discuss the materials that students will have available, including any limits you will place on the minimum and maximum size of their scale model (for example, it has to be smaller than the cardboard base where they will build their model), as well as limits on the type and quantity of materials. Ask students to consider the criteria set earlier in the lesson as well as:

- The needs of the astronauts (4 astronauts for 1 month) (Size, different areas)
- Properties of regolith, especially if they are using a regolith-type material for 3D printing their scale model
- What they learned from the Earth structures earlier in the lesson.

Circulate as students work on conceptual plans first, and then, once you have discussed their conceptual plans, they can transition to design plans. Their design plans should include, at a minimum:

- Labeled floor plan of the habitat, including what each area is used for and enough size measurements to help understand the overall size of the model. If the habitat has multiple floors, include each floor plan.
- All of the “must have” spaces for astronauts to use, listed in the Explore portion of the lesson
- Scale factor of the model compared to the actual habitat
- Construction Plan - how will they build it? This can be a written or verbal plan.

As students finish their design documents, they can be approved to continue on with building their scale models.

Elaborate (90 Min): *Students will build their scale model habitats.*

Provide students with their materials and ask them to build their scale models according to their design drawings. Decide if you will allow them to change their design drawings if they think of a better design, and what your process will be for them to create new design drawings. For example, must they get changes approved by you first? Do they need to provide a reason for the change?

If you want to use the 3D pen, this video will help you get started.

Mini-Mission 10: Investigating Water on Earth and the Moon

Full Lesson:
https://nwessp.org/lesson/artemis-iii-3/

Summary: *Students will explore how water moves through the water cycle on Earth and how this knowledge can help astronauts access clean water on the Moon. They will conduct hands-on experiments to investigate water purification methods inspired by natural processes.*

Estimated Time: 5 hours

Engage (30 minutes): Students will consider where their drinking water comes from at school, at home, and in their community.

Campers will begin by discussing where their drinking water comes from and how water becomes contaminated. Say: *"Imagine that you are very, very thirsty and need a drink of water. You need a drink of water more than you've ever needed one in your life. Your mouth is dry and all you can think about is a drink of cool, refreshing water. You go to the water fountain here at school (or to the sink with a water bottle or cup) and turn it on."*

- Where does our drinking water come from?
- Is the source of your drinking water the same at school as at home?
- Are there other sources of drinking water in our community?
- If you are not sure of the answers to any of these questions, how could you find out?

Give students time and assistance in researching these ideas. You should also spend some time discovering the answer to these questions yourself.

After discussing what the students already knew or discovered, pose these new questions:

- Is our water safe to drink? How would we know?
- How might water become unsafe to drink (contaminated)? There is more than one way!

Say: *"We are going to learn more about where our water comes from, how we know if it is safe to drink, ways to clean water for drinking, and what this means for astronauts on the Moon. "*

Engage (180 minutes): Students will play two versions of a water cycle game and engage with hands-on activities to understand how the water cycle works to move, change, contaminate, and purify water.

Part 1: Water Cycle Game

Thoroughly review the Water Cycle Game directions and watch the teacher-facing instructional videos (Part 1: No Contaminants, Part 3: Contamination Cards), decide the style of game play you will use (whole group or small group, table-top or online) and prepare the materials and print-outs accordingly.

Before you begin, make sure that each student has a copy of the “Part 1” student handout (included in the student workbook) and go over how the game works and what they should be recording. For example, all students will start at a station and list it as “Start at” in Row 1. They will roll their dice and see what the Station Card directs them to do and write their new station under “Move to” in Row 1. This new station then gets entered as the “Start at” station in Row 2. They should continue this until they have filled out all 10 rows.

After all students have finished 10 moves, it is time for small group discussion. If students are already in groups, they can stay in those groups to discuss or form new groups. If students are not already in groups, form groups of 4.

First, ask students to compare the “path” that each member of their group took as they move through the water cycle. Ask them to consider:

- Did you all start at the same station? Did you all follow the same path? Did anyone visit all 9 stations? Who visited the fewest stations?
- This game is about the water cycle. What does the word “cycle” mean to you? Did you move in a “cycle” in this game?
- Compare the game we just played to this common way that the water cycle is often shown (optional: display on the slide from the resource folder). How are they similar? How are they different?

Circulate as students discuss. Bring the class back together as a group and call on a few students who had good insights into the questions above, based on your circulating among them as they spoke. If a student had a particularly “interesting” or strange path in the game (for example, if someone never left the ocean or visited all 9 stations), you may wish to share those with the whole class.

Next, ask students to consider how and why the water might be moving or changing in their game. Students can fill this out in the note section of Part 1 in the student workbook.

Part 2: Water Cycle Investigations

Next, they will conduct quick experiments that model key water cycle processes. Through hands-on experiments, students will explore evaporation, filtration, sedimentation, and freezing—key processes that influence water quality on Earth and could be adapted for use on the Moon.

Students can either rotate through multiple experiments, work in small groups on one experiment and share their findings, or observe demonstrations led by the instructor. No matter the approach, they should record observations and consider how each process affects water cleanliness.

Materials and directions are available on the student workbook “Water Experiment Recording Sheet.” To learn more about what these experiments should look like we have also provided a teacher-facing instruction video that describes each experiment. Direct students to record their observations (with words and diagrams, if appropriate) but leave the “Discussion Notes” section blank for now. Some teacher tips and extension options are listed below:

After conducting or observing these experiments, students will discuss their results. They should compare which methods cleaned the water most effectively, which worked the fastest, and whether any produced water that seemed safe to drink. To deepen their understanding, students will connect their findings to the water cycle game, identifying where each process occurs in nature.

By the end of the activity, students will see how water purification happens naturally and begin to think about how these processes could be adapted for astronauts who need clean water in space.

Part 3: Water Cycle Game with Contaminants

This activity expands on the water cycle game by introducing contaminants—salt, sediment, and E. coli—to help students understand how water can become polluted and how natural processes help clean it. Again, there is a teacher-facing instruction video that describes this version of the game.

Before playing, discuss these contaminants and where they are commonly found. Students should consider how salt enters the water system, where sediment is most likely to collect, and how bacteria like E. coli can spread. Using the modified station cards, students will track when they pick up and put down contaminants as they move through the water cycle.

As students complete their game rounds, they will record their results in their student workbook and reflect on what happens to contaminated water. Small group discussions will encourage them to analyze their findings, focusing on whether contaminated water stays "dirty forever" or if natural processes remove pollutants over time.

Encourage students to connect their game experience to previous water experiments. For example, they should recognize that water loses salt through evaporation, mimicking the natural purification process. Through these discussions, students will gain a deeper understanding of how water moves, how it can become polluted, and how Earth's water cycle helps maintain clean drinking water—lessons that are critical when considering how astronauts will manage water in space.

Elaborate (90 minutes): Students will construct and test a prototype inspired by the water cycle to purify water on the Moon.

For this activity, students will design and test a prototype inspired by the water cycle to purify water, just as astronauts will need to do on the Moon. Depending on available materials and time, instructors may choose to focus on simple water filtration devices as the most efficient option. While all students should follow the same general process, they should have the freedom to make design choices, ensuring a variety of approaches and solutions. Students can keep a record of their work using the Engineering Design Process sheets in their student workbook.

Begin by introducing students to the challenge and the materials they can use. They should first decide what type of contamination they will attempt to remove, such as potting soil, food coloring, or salt. Then, they will select a purification method that mimics natural processes—options include filtration, evaporation and condensation, settling, or freezing. Students may need to refer back to previous experiments and discussions about the water cycle to inform their decisions.

Once they have a plan, students should sketch their design and determine what measurements they will take. They should record the initial amount of water, the purification time, and the final amount of clean water collected. Observations should include both qualitative changes, such as clarity, and quantitative data, such as water volume before and after purification.

With their plans in place, students will build and test their prototypes, documenting the process through notes, sketches, or photos. If time allows, they can refine their designs, making adjustments based on their observations to improve efficiency.

After testing, students will evaluate their results. They should consider how effective their system was, how much water it purified over time, and whether the water would be safe to drink. Encourage discussion on how these methods could be adapted for use in space, where resources are limited, and efficient water recycling is essential.

Mini-Mission 11: Mission Patch Development

Full Lesson:
https://nwessp.org/lesson/artemis-roads-unit-1-lesson-3/

Summary: *First, students will consider how symbols can convey information and examine examples of mission patches. Then, they will work together to create their own mission patch for the project. Next, students will learn about many of the different people who contribute to the Artemis mission and consider what roles they are most interested in. Finally, they will record their mission patch and career information in their MDL.*

Estimated Time: 2 hours

Engage (30 minutes): Students will consider how to convey information about themselves, their communities, and the project using only symbols.

Share the following prompt with students. Give them 3 minutes in the alone zone before asking them to share ideas with a partner, and then with their project groups.

"If you had to describe something important to you with symbols only (no words), how would you do it? What symbols could show what is important to you, your family, your community?"

Students will examine several mission patches from former NASA missions provided by NESSP and try to understand what each mission was about based on the patch. Then, they will learn more about the patches and the missions they represent to help launch their own patch designs.

Say: "One important step of all NASA missions is to design the mission patch. Each group will design a patch based on all of the work we have done on our mission. You will also choose a team name."

First, we are going to look at some examples in the slides in the resource folder that might help you consider ways to incorporate your personal symbols....

	The first two slides have examples of mission patches that are culturally relevant. Show these in slideshow mode, and start by asking students what they notice. Clicking through the slides will reveal the meaning behind these images. Then, ask students to answer the following reflection questions: ● To determine a patch shape: does your community have emblems, seals, objects with distinctive shapes that are important to the community? ● To represent the team/spacecraft: for your community, when you think of 'flight' or 'trip' what comes to mind? Or, what has historically connected the Earth with the sky/heavens/cosmos? ● To represent the Moon: does your community have any important/ significant stories related to the Moon? ● To represent the Earth: does your community have any important/

	significant stories related to the Earth? What does the Earth represent to you and/or your community? ● For your designs: what colors are important to you and/or your community? ● For your text/team name: what languages are important to you and/or your community? Are there any fonts that are important to you and/or your community?

Display the third and fourth slides of the slide show (Artemis Mission Patch). Again, ask students what they notice before clicking through the slide to reveal what NASA considered when designing these emblems.

Now, students will have a chance to analyze mission patches in pairs or small groups. Display Slide 5. Assign pairs or groups of students to each mission patch example or allow them to choose. Ask students to discuss the patches with a partner or group of 4. What do they notice and what do they wonder about the patches?

Give students 10 minutes to discuss in their pair or small group. If students are not already in groups of 4, assign groups of 4. Then, assign one patch to each student in the group and give them access to the slide for their patch (Slides 6 - 9). (NOTE: The readings about the patches are not equal in length; consider which students receive which assignment.)

Instruct students to read the information on their patch and mission to see if it confirms what they noticed about the patch, as well as any new information that is added. Once all students have had a chance to read about their patch, they should assemble with their group of 4 and take turns sharing information that they learned.

Revisit “Engage” question--do students have new ideas about how to represent themselves, their communities, and the mission?

	Consider local art and craft approaches as well! This is a great opportunity for you to incorporate traditional art forms in your lesson. You can have your students review the following map for inspiration. Local and Cultural Art Forms to Inspire Your Mission Patch (MO-2) **Note to teachers:** this Padlet shows examples of local and cultural art forms that may help inspire your student’s mission patch design and creation. If you have some examples that you would like to add for your community please click the plus symbol (+) in the bottom right corner of the map. New additions are vetted and approved by NESSP before appearing.

Explore (60-90 minutes): Students will choose a team name and design their mission patch.

Each team should collaborate to create one mission patch for their team. Students can create their mission patch in any format or medium that they desire, including a poster, digital media such as Canva or Adobe Illustrator, or anything else.

After students have created their mission patches, they should share them and get feedback.

Mini-Mission 12: Final Performance and Presentation

Students are asked to create a presentation, with or without slides, that includes the following information:

- [ ] A *brief* description of the Moon. Set the scene for your mission! Why would you send a mission to the Moon?
- [ ] Present what you did for some of the mini-mission you completed this week. Include a summary, describe what you learned, and include photos or examples of your work when possible.
- [ ] Finally, wrap it all up with a quick summary!

You should determine the most appropriate mode for these presentations based on your learning environment and the age of the students. You also need to determine how much time each team gets to present their results and address questions based on the amount of time you have and the number of teams. You may have older students give a formal presentation to their campmates and family/friends. For younger students, it may be more appropriate to have a less formal show-and-tell session with the students sitting in a circle.

Appendix:

Name tags:

NESSP will provide a name tag template and lanyards for your mini-mission scientists to registered instructors. The name tag template is in the resources folder.

Certificate of completion and awards:

Blank certificates of completion templates are also provided in the resources folder.

Additional Activities:

College Admission and Scholarship Search:

First-generation or underrepresented students in high school often don't understand that there are resources to help them pay for college. For example, many low-income students don't know that many ivy league schools will offer them full-tuition scholarships. For high school students, you can have them list the schools they might be interested in attending and then spend some time helping them understand the financial aid offered at that school.

We recommend you start with a video like this one from QuestBridge: https://www.youtube.com/watch?v=KNZndnqRxQs

Next you can hand out the scholarship resources sheet and give students time to explore. It may be useful to remind students about the deadlines, what type of information they will need, and who at their school can help them.

College Student Panel:

With advanced notice NESSP may be able to set up a virtual panel of college students for your campers to talk to. The students can give perspective on their own unique paths to college and then take questions from the students. This activity can help the students see that there are a variety of ways to become a successful college student. Please email info@nwessp.org if you would like to set up a panel.

STEM Career Exploration:

It can be useful for students (high school students especially) to look at what type of careers are available in the industry they want to pursue. For example, students are often surprised at what type of skills and degrees are requested for applicants to SpaceX or Blue Origin.

Have the students think about what type of career they are interested in and what companies or organizations they would like to work for. Then help them use a browser to navigate the job advertisements of those companies/organizations. Ask individuals or groups of students to report back what job they found most interesting and what type of degree qualified you for that job. They can also report back any other information they found to be interesting or surprising.

Science Matter Expert Presentations:

During the academic year, the Artemis ROADS, Artemis ROADS II, and Artemis ROADS III challenges had “NASA Expert” (NASA employee) presentations and question and answer sessions. Although the students in your mini-mission are not able to interact with these experts live, they may still enjoy watching the presentation and learning more about scientists and engineers who work for NASA. Each presentation is about ~30 minutes long and can be found on NESSP’s YouTube channel https://www.youtube.com/c/nwessp.

Tie-Dying Shirts:

NESSP can provide materials to tie-dye the shirt provided as part of the camp. This fun activity will give the students unique memorabilia of their mini-mission!

We recommend this die kit:
https://www.amazon.com/Tulip-One-Step-Tie-Dye-Kit-Activity/dp/B08XM1W9L2/ref=sr_1_20?crid=RREFQG32HX4K&keywords=galaxy+tie+dye+kit&qid=1651179558&sprefix=galaxy+tie+%2Caps%2C253&sr=8-20

If possible, you should do this activity outside. When campers are done dying the shirts, put them in a large zip-lock back and send them home with the campers to be washed and dried. If the students' parents aren’t able to wash and dry the shirts, offer to take a set home to do yourself.

Artemis ROADS Mini-Mission Materials List:

MM 1: Artemis Lotería

Provided by instructor:	Provided by NESSP
None	☐ Lotería game, one or two sets

MM 2: Destination Moon

Provided by instructor:	Provided by NESSP
☐ Computers, laptops, or tablets if using simulation, one ever 2 students if possible*	None

MM 3: Life in a Closed System

Provided by instructor:	Provided by NESSP
☐ Small plants (like plant starts), one per team ☐ 1 or 2 liter bottles or other airtight container, one per team ☐ Packing or Duct Tape	☐ Grow lights & Clamp lamps ☐ CO_2 Detectors ☐ Thermometers

MM 4: Pack Your Moon Kit

Provided by instructor:	Provided by NESSP
None	None

MM 5: Investigate the Moon's Surface

Provided by instructor:	Provided by NESSP
☐ Computers, laptops, or tablets if allowing students to explore resources directly*, one per team	None

MM 6: Rover Development and Surface Navigation

Provided by instructor:	Provided by NESSP
☐ Cardboard (or plywood or foam board) and other ramp building supplies, one per team or shared ☐ Computers, laptops, or tablets if allowing students to explore resources directly*, one per team	☐ Lego SPIKE Robots, one per team ☐ Moon and yellow path Lego practice mats, one per team ☐ General Lego practice mat, one per team ☐ Rulers, one per team ☐ Protractor, one per team ☐ Colored delivery target printouts or full map, one or two sets ☐ Colored blocks (delivery packages) ☐ Lunar tunnel segments, one or two sets

MM 7: Craters

Provided by instructor:	Provided by NESSP
☐ Cameras if taking images of craters ☐ Bins for impact basin, one per team ☐ Flour, one per team ☐ Cocoa powder, one per team	☐ Impactors (marbles or similar), one per team

MM 8: Getting to the Moon

Provided by instructor:	Provided by NESSP

☐ 1 or 2-liter water bottles
☐ Lubricant for nozzle of water bottle
☐ Other building supplies:
    ☐ Duct or packing tape
    ☐ Sturdy cardboard or balsa wood
    ☐ Tape (clear packing tape or duct tape is preferable)
    ☐ Glue (hot or quick drying gel glue is preferable)
    ☐ Scissors and/or box cutters
    ☐ Rulers
	☐ Aquapod Launcher & Petroleum Jelly
	☐ Bike pump
	☐ Estes Altitude Tracker
	☐ Wooden Dowels
	☐ Clay

MM 9: Build a Habitat

Provided by instructor:	Provided by NESSP
☐ Cardboard ☐ Pastry bags or zip lock bags ☐ Other building supplies (optional)	☐ 3D Pens ☐ Lunar Regolith ☐ Masks and gloves for working with regolith

MM 10: Investigating Water on Earth and the Moon

Provided by instructor:	Provided by NESSP
☐ Materials for water cycle experiment and filtration device, e.g. glass beaker or cup, plastic wrap, rubber banda, food coloring, soil/dirt, coffee filters, access to a freezer	☐ Water Quality Testing Pen ☐ Printouts of the Water Cycle game sheets and cards

MM 11: Mission Patch Development

Provided by instructor:	Provided by NESSP
☐ Markers or colored pencils	☐ Sets of Mission Patches from STEAM4SPACE

MM 12: Final Performance and Presentation

Provided by instructor:	Provided by NESSP
☐ Markers or colored pencils	None

Additional Supplies provided by NESSP:

- ☐ Lanyards, one per student
- ☐ Tie-Dye Supplies, one per ~10 students
- ☐ T-shirts, one per student if sizes are provided in time
- ☐ Name tag and certificate templates are available to print at: Artemis ROADS Resources for Instructors