



Strange New Planet

Grades: K-8

Prep Time: ~45 Minutes

Lesson Time: 2 Hours



WHAT STUDENTS DO: Explore a Model Planet to Discover New Features

Students find out how human curiosity in planetary exploration results in science questions, engineering solutions, and teamwork. This activity demonstrates how planetary features are discovered by the use of remote-sensing techniques. Students will experience the different phases in planetary exploration, including telescope observations, fly by missions, orbiters, landers, rovers...and their own ideas about human exploration. In this collection, this lesson provides one of the building blocks for understanding the relationship among science, engineering, technology, and teamwork, necessary to discovery and innovation.

NRC CORE & COMPONENT QUESTIONS

HOW ARE ENGINEERING, TECHNOLOGY, SCIENCE, & SOCIETY INTERCONNECTED?

NRC Core Question: ETS2: Links among engineering, technology, science, & society

What are the relationships among science, engineering, & technology?

NRC ETS2.A: Interdependence of Science, Engineering, & Technology

INSTRUCTIONAL OBJECTIVES

Students will be able

IO1: to produce a concept for an investigation that requires science questions, engineering and technological solutions, and teamwork



1.0 About This Activity

This activity is part of the Imagine Mars Project, co-sponsored by NASA and the National Endowment for the Arts (NEA). The Imagine Mars Project is a hands-on, STEM-based project that asks students to work with NASA scientists and engineers to imagine and to design a community on Mars using science and technology, then express their ideas through the arts and humanities, integrating 21st Century skills. The Imagine Mars Project enables students to explore their own community and decide which arts-related, scientific, technological, and cultural elements will be important on Mars. Then, they develop their concepts relating to a future Mars community from an interdisciplinary perspective of the arts, sciences, and technology. imaginemars.jpl.nasa.gov

The Imagine Mars lessons leverage *A Taxonomy for Learning, Teaching, and Assessing* by Anderson and Krathwohl (2001) (see *Section 4* and *Teacher Guide* at the end of this document). This taxonomy provides a framework to help organize and align learning objectives, activities, and assessments. The taxonomy has two dimensions. The first dimension, cognitive process, provides categories for classifying lesson objectives along a continuum, at increasingly higher levels of thinking; these verbs allow educators to align their instructional objectives and assessments of learning outcomes to an appropriate level in the framework in order to build and support student cognitive processes. The second dimension, knowledge, allows educators to place objectives along a scale from concrete to abstract. By employing Anderson and Krathwohl's (2001) taxonomy, educators can better understand the construction of instructional objectives and learning outcomes in terms of the types of student knowledge and cognitive processes they intend to support. All activities provide a mapping to this taxonomy in the Teacher Guide (at the end of this lesson), which carries additional educator resources. Combined with the aforementioned taxonomy, the lesson design also draws upon Miller, Linn, and Gronlund's (2009) methods for (a) constructing a general, overarching, instructional objective with specific, supporting, and measurable learning outcomes that help assure the instructional objective is met, and (b) appropriately assessing student performance in the intended learning-outcome areas through rubrics and other measures. Construction of rubrics also draws upon Lanz's (2004) guidance, designed to measure science achievement.

How Students Learn: Science in the Classroom (Donovan & Bransford, 2005) advocates the use of a research-based instructional model for improving students' grasp of central science concepts. Based on conceptual-change theory in science education, the 5E Instructional Model (BSCS, 2006) includes five steps for teaching and learning: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage stage is used like a traditional warm-up to pique student curiosity, interest, and other motivation-related behaviors and to assess students' prior knowledge. The Explore step allows students to deepen their understanding and challenges existing preconceptions and misconceptions, offering alternative explanations that help them form new schemata. In Explain, students communicate what they have learned, illustrating initial conceptual change. The Elaborate phase gives students the opportunity to apply their newfound knowledge to novel situations and supports the reinforcement of new schemata or its transfer. Finally, the Evaluate stage serves as a time for students' own formative assessment, as well as for educators' diagnosis of areas of confusion and differentiation of further instruction. This five-part sequence is the organizing tool for the Imagine Mars instructional series. The 5E stages can be cyclical and iterative.



2.0 Materials

Required Materials

Please supply:

For making “strange new planets”

- Modeling clay or play-dough
- Choose among: plastic balls, foam balls, sequins, round fruit, perfume, essential oils, candy, small stickers, marbles, cotton balls, glue, toothpicks, marshmallows, beads

For viewing “strange new planets”

- Sheets of paper, paper towel rolls, toilet paper rolls, or paint roller tubes
- Rubber bands
- 5”X5” clear, blue cellophane squares

Facility

- A room where students can easily move around. If it is too difficult to change the arrangement of a classroom or small space, consider doing the activity outside or in a more open room, such as a cafeteria or a gym.

Other:

- cloth or towel
- push pins
- masking tape
- colored pencils or crayons

Please Print:

From Student Guide:

- | | |
|----------------------------------|-----------------|
| (A) Telescope Observations | – 1 per student |
| (B) Fly-by Mission Observations | – 1 per student |
| (C) Orbiter Mission Observations | – 1 per student |
| (D) Lander Mission Plan | – 1 per student |
| (E) Comparison of Mission Types | – 1 per student |
| (F) Humans to Mars Concept | – 1 per student |

Optional Materials

From Teacher Guide:

- (G) Mars Mission Facts
- (H) “Strange New Planet” Assessment Rubrics
- (I) Alignment of Instructional Objective(s) and Learning Outcome(s) with Knowledge and Cognitive Process Types



3.0 Vocabulary

Ask questions	scientists asks questions that can be answered using empirical evidence
Fly by	a spacecraft designed to go by a planet and study it on its way past
Empirical Evidence	knowledge gained through direct or indirect observation
Lander	a spacecraft designed to explore on the surface of a planet from a stationary position
Mission	a spacecraft designed to explore space, seeking to answer scientific questions
Models	a simulation that helps explain natural and human-made systems and shows possible flaws
Observations	specific details recorded to describe an object
Orbiter	a spacecraft designed to explore space, seeking to answer scientific questions
Rover	a robot designed to travel on the surface of a planet
Planet	a sphere moving in orbit around a star (e.g., Earth moving around the sun)

4.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

Instructional objectives, standards, and learning outcomes are aligned with the National Research Council's *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, which serves as a basis for upcoming "Next-generation Science Standards." Current National Science Education Standards (NSES) and other relevant standards are listed for now, but will be updated when the new standards are available.

The following chart provides details on alignment among the core and component NRC questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the NRC Framework and education standards.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO)**.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics** (see Teacher Guide at the end of this lesson).



Quick View of Standards Alignment:

The Teacher Guide at the end of this lesson provides full details of standards alignment, rubrics, and the way in which instructional objectives, learning outcomes, 5E activity procedures, and assessments were derived through, and align with, Anderson and Krathwohl's (2001) taxonomy of knowledge and cognitive process types. For convenience, a quick view follows:

HOW ARE ENGINEERING, TECHNOLOGY, SCIENCE, & SOCIETY INTERCONNECTED?			
<i>NRC Core Question: ETS2: Links among engineering, technology, science, & society</i>			
What are the relationships among science, engineering, & technology?			
<i>NRC ETS2.A: Interdependence of Science, Engineering, & Technology</i>			
Instructional Objective <i>Students will be able</i>	Learning Outcomes <i>Students will demonstrate the measurable abilities</i>	Standards <i>Students will address</i>	Rubrics in Teacher Guide
<p>IO1:</p> <p>to produce a concept for an investigation, requiring science questions, engineering and technological solutions, and teamwork</p>	<p>LO1a. to generate science questions and answers</p> <p>LO1b. to explain how different types of engineering and technological solutions help answer different science questions</p> <p>LO1c. to explain the advantages of working in teams</p>	<p>NSES (A): SCIENCE AS INQUIRY: Abilities Necessary to Do Scientific Inquiry</p> <p>Grades K-4: A1a Grades 5-8: A1a</p> <p>Understandings about Scientific Inquiry</p> <p>Grades K-4: A2a Grades 5-8: A2a</p> <p>NSES (E): SCIENCE & TECHNOLOGY: Understandings about Science & Technology</p> <p>Grades K-4: E1a, E1b, E1e Grades 5-8: E1a, E1c</p> <p>NSES (E): SCIENCE & TECHNOLOGY: Understandings about Science & Technology</p> <p>Grades K-4: E1c, E1d Grades 5-8: E1b</p>	



This activity also aligns with:

NRC SCIENCE & ENGINEERING PRACTICES

- 1) Asking questions (for science) and defining problems (for engineering)
- 3) Planning and carrying out investigations

NRC SCIENCE & ENGINEERING CROSSCUTTING CONCEPTS

- 4) Systems and system models

21ST CENTURY SKILLS

- Critical Thinking and Problem Solving
- Communication
- Collaboration
- Initiative and Self-Direction

5.0 Procedures**PREPARATION** (~45 minutes)**Constructing the “Strange New Planet”**

- A.** Take Play-Doh or modeling clay and form a ball (the planet). You can use multiple colors if you would like. Decorate the object with stickers, scents etc. to make the object interesting to observe. Some of these materials should be placed discreetly so that they are not obvious upon brief or distant observations. Making some suggested features include:
- a. creating clouds by adding cotton
 - b. carving channels in the Play-Doh or clay
 - c. attaching a grape or marshmallow using a toothpick
 - d. using small beads to make craters in the Play-Doh or clay
 - e. affixing small stickers (perhaps with a picture of a bug to signify life)
 - f. embedding beads or other small objects in the Play-Doh or clay
 - g. applying scent sparingly to a small area

🍏 Differentiation Tip: For older or more advanced students, form teams and allow each to create their own planets for other teams to view. This opportunity allows students to create their own set of planetary features and create a key. These features can then be compared with those found on other teams' planets.



- B. Place the object (planet) on a desk or table in the back of the room. Make sure the “back side” of the planet has something interesting that can’t be seen from its front side. Cover the object with a towel before students arrive.
- C. Use masking tape on the floor to create a 2” distance and a 5” distance around the desk or table.

Constructing the Planet Viewers

- D. Construct viewers (or have students construct viewers) out of loose-leaf paper by rolling the shorter side into a tube (or supply an empty toilet paper or paper towel roll or paint roller tubes).
- E. Place one clear, blue cellophane square over one end of the tube and attach with a rubber band.

Printing:

- F. Please print handouts (A) – (F) in the Student Guide

STEP 1: ENGAGE (~10 minutes)


How Science & Engineering Come Together in Planetary Exploration

- A. Tell students they have a mission. They are scientists who have just discovered a strange new planet, and their job is to find out all about it. They will be exploring this new world in the same way that NASA explores the solar system. Discuss the idea that people have questions about the natural world and that observations and measurements using technology tools helps us find answers (see standards, Section 4.0).
- B. If desired, provide a first-person account through storytelling.

“Let me tell you a story about Dr. Christensen, a scientist who studies Mars today. He was interested in space since he was a kid. “Dr. C” remembers how people’s ideas about Mars changed tremendously after the first spacecraft went to Mars. In the late 1950s, people thought Mars had plants, a thick atmosphere (air), and was a lot like Earth. Encyclopedias like *The World Book Encyclopedia* and publications like *National Geographic* had articles describing Mars like Earth. Our first spacecraft to Mars sent back the first photographs of another planet ever—in 1965. When we got those pictures, our ideas of Mars changed forever. Mars was not a lush green planet, but a barren, desert-like planet. That information helped NASA plan missions that followed, including orbiters, landers, and rovers. Each mission



brought new information that led to new questions. New questions lead to new discoveries. You're going to find that out in exploring your own "strange new planet." (See also Extensions.)

 **Curiosity Connection Tip:** For making a connection to NASA's Mars Rover "Curiosity," please show your students additional video and slideshow resources at:


<http://mars.jpl.nasa.gov/participate/marsforeducators/soi/>

STEP 2: EXPLORE (~45 minutes)

How Engineering & Technology Support Science Questions

Telescope Observations from the Earth's Surface

- A. Arrange Mission Teams (4-5 students) against the front of the room, or opposite the wall with the table and the cloth-covered "strange new planet." Tell students that they are standing in "Mission Control."
- B. Hand out (A) *Earth-based Observation Worksheet* to each team.
- C. To simulate Earth's atmosphere, place a blue cellophane sheet on the end of the viewers, held in place by a rubber band. Tell the students that the tube represents a telescope located on the surface of the Earth and that the blue cellophane represents Earth's atmosphere.
- D. Tell students they will have the first look at the "strange new planet" with their telescopes. Lift the towel. Allow the team to observe the planet(s) with viewers for 30 seconds.
- E. Replace the towel. Tell teams to discuss and record their observations on (A) *Telescope Observation Worksheet*.

 **Teacher Tip:** Most of the observations at this point will likely be visual in nature, such as color, shape, and texture.

Telescope Observations from above the Earth's Atmosphere

- A. Ask students to remove the blue cellophane and take one-step forward. Tell them that their viewer is now a space telescope (like the Hubble) and that the atmosphere no longer obscures their view.
- B. Tell students that a space telescope is expensive, and many scientists want time to use it to answer their questions. So, they have short scheduled times to use it.
- C. Lift the towel again and allow students to observe the planet(s) with viewers for 30 seconds. Cover the planet.



- D. Allow students to record any additional observations on the *(A) Telescope Observation Worksheet*.
- E. Ask students to create questions they have about the planet, based on their observations.

Fly By of the Planets

- A. Ask students at their mission control stations to turn their backs to the planets until it is time to do their mission.
- B. Uncover the front part of the planet, but keep the backside covered by the cloth.
- C. Ask students in the first team to raise their viewer to their eyes. Tell them that they will have a chance to pretend to be a spacecraft that will quickly fly by the planet, but cannot cross the masking-tape line around the table. Have the first team turn around and make a pass by (fly by) the planet, and return to Mission Control, keeping their backs turned once there. Repeat with remaining teams.
- D. Once all teams have conducted their fly by mission, replace the towel.
- E. Hand out a *(B) Fly-by Observation Worksheet* to each student. Give students an opportunity to record their observations and discuss what questions they have for an orbital mission.

Orbiting the Planets


- A. Ask students at their mission control stations to turn their backs to the planets until it is time to do their mission.
- B. Uncover all sides of the planet.
- C. Tell each mission team they have one minute to orbit (circle) the planet at a distance of no more than 2 feet, looking through their viewer. Allow each team to conduct their mission and return to mission control.
- D. Hand out a *(C) Orbiter Observation Worksheet* to each student. Give students an opportunity to record their observations and discuss what questions they have for an orbital mission.

Landing on the Planets


- A. Hand out a *(D) Lander/Rover Mission Plan* to each student. Tell students they will develop a mission plan for their landing expedition onto the planet's surface. Mission plans should include the landing spot and feature to be examined based on their interests and science questions from prior observations. Teams will have to agree on one place to examine.
- B. Using a pushpin, have a mission team member approach the selected landing site and mark it. (Use masking tape or a sticker if the pin would damage the planet.)



- C. Tell each mission team that they have one minute to look at their landing site through their viewers. So that they all see the same things through their viewers, instruct students to line up the location of the pushpin in their “field of view” in the viewer in a common place (inside the viewer, at the top of their view, in the center.

 **Teacher Tip:** To illustrate, draw a simple circle on the board and mark the position of the pushpin at top center of the circle.

- D. When team members have observed the landing site to record their observations and discuss answers to their science questions.

 **Curiosity Connection Tip:** For making a connection to NASA’s Mars Rover “Curiosity,” please show your students additional video and slideshow resources at:

<http://mars.jpl.nasa.gov/participate/marsforeducators/soi/>

STEP 3: EXPLAIN (~10 minutes)

How engineering and technology support answering scientific questions.

- A. Hand out (E) *Comparisons of Mission Types*.
- B. Share information about the history of Mars Exploration or have them research online about Mars missions so far (see Teacher Guide at the end of this lesson.) Ask students to compare mission types based on their own observations of the strange new planet and the history of mission types in Mars Exploration.

STEP 4: ELABORATE (~10 minutes)

Planning a New Mission.

- A. Tell students they are going to plan the first human mission to Mars, which will involve the ideas of teams from many nations and people from many cultures. Explain that this mission may be the first step in many before we can establish a community there.
- B. Allow each team to choose a country or culture to represent. The culture can be real or imagined, based on a common heritage, a common aspiration for their mission or science question of interest, or simply team names (e.g., Blue Team, Red Team etc.).
- C. Hand out (F) *Mission Concept for the First Human Mission to Mars* and allow each team to complete the first section, with each team member contributing at least one idea for inclusion. Tell each team that all team members should pick at least one science question they would want astronauts to answer and their ideas about what kind of engineering and technological solutions would be needed.



STEP 5: EVALUATE (~60 minutes)

Assessing Proposed Strengths and Weaknesses of Missions.

- A. Ask each team to present the ideas for their mission to other teams, with each team member explaining at least one science question related engineering and technological solutions that would be needed.
- B. As each team presents, have other teams complete the second section of *(F) Mission Concept for the First Human Mission to Mars*.
- C. Collect student work and use rubrics to evaluate their current level of proficiency.

6.0 Extensions

As a homework activity, ask students to follow their curiosity about Mars. Ask them to go online (with the parents, if their age suggests it), and ask “Dr. C” at least 3 questions about Mars. Have them write down the following url: <http://marsdata1.jpl.nasa.gov/DrC>

7.0 Evaluation/Assessment

Use the *(H) Strange New Planet Rubric* as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using and National Science Education Standards.

8.0 References

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