



## 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

*See Section 4.0 and Teacher Guide at the end of this lesson for details on Instructional Objective(s), Learning Outcomes, Standards, & and Rubrics.*



## 1.0 About This Activity

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



### 3.0 Vocabulary

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

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

**21<sup>ST</sup> 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

- Anderson, L.W., & Krathwohl (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman.
- Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications*. Colorado Springs: BSCS.
- Donovan, S. & Bransford, J. D. (2005). *How Students Learn: History, Mathematics, and Science in the Classroom*. Washington, DC: The National Academies Press.
- Lantz, H.B. (2004). *Rubrics for Assessing Student Achievement in Science Grades K-12*. Thousand Oaks: Corwin Press.
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- National Academies Press. (1996, January 1). *National science education standards*. Retrieved February 7, 2011 from [http://www.nap.edu/catalog.php?record\\_id=4962](http://www.nap.edu/catalog.php?record_id=4962)
- National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
- The Partnership for 21<sup>st</sup> Century Skills (2011). *A framework for 21<sup>st</sup> century learning*. Retrieved March 15, 2012 from <http://www.p21.org/>



**(A) Student Handout. Telescope Observations**

NAME: \_\_\_\_\_

**1. Explain how you think we know about the planets and moons in our solar system.**

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**2. Record Your Observations.**

**Draw**

**Describe**

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**3. Based on your observations, record your questions for future exploration.**

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**(B) Student Worksheet. Fly By Mission Observations**

NAME: \_\_\_\_\_

**1. Record Your Observations.**

**Draw**

**Describe**

Draw	Describe

**2. Which of your questions (based on your “telescope” observations) did the fly-by mission answer? What are the answers?**

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**3. What new or remaining questions do you have for a future spacecraft that can orbit the planet?**

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**(C) Student Worksheet. Orbiter Mission Observations**

**1. Record Your Observations.**

**NAME:** \_\_\_\_\_

**Draw**

**Describe**

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**2. Which of your questions (based on your “telescope” and fly-by observations) did the orbiter answer? What are the answers?**

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**3. What new or remaining questions do you have for a future spacecraft that can land on the planet?**

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**(D) Student Worksheet. Lander/Rover Mission Plan (1 of 2)**

**1. Plan Your Observations.**

NAME: \_\_\_\_\_

**Draw the Landing Site**

**Describe Features to Observe**

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**2. How did your team decide on a landing site?**

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**(D) Student Worksheet. Lander/Rover Mission Plan (2 of 2)**

NAME: \_\_\_\_\_

**3. Record Your Observations.**

Draw	Describe

**4. Which of your questions did this mission answer? What are the answers?**

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**(E) Student Worksheet. Mission Type Comparisons (1 of 3)**

NAME: \_\_\_\_\_

1. In the tables below, list the kinds of information you can collect from each type of mission, as well as the advantages and disadvantages of using each type.

Mission Type	Type of Information	Advantages	Disadvantages
Telescope Observations			
Fly By Missions			

**(E) Student Worksheet. Mission Type Comparisons (2 of 3)**

NAME: \_\_\_\_\_

1. In the tables below, list the kinds of information you can collect from each type of mission, as well as the advantages and disadvantages of using each type.

Mission Type	Type of Information	Advantages	Disadvantages
Orbiter Missions			
Lander/Rover Missions			



**(E) Student Worksheet. Mission Type Comparisons (3 of 3)**

NAME: \_\_\_\_\_

In addition to engineering and technology, teamwork among people with different perspectives is important in answering science questions. Reflect on the following:

Question	My Thoughts
1. What were the advantages of working on a team to study the “strange new planet”?	
2. What were the disadvantages of working on a team to study the “strange new planet”?	
3. What could you do to encourage good teamwork in the future?	
4. Why is it important for many people with different perspectives and backgrounds to work together?	
5. How do you think scientists and engineers benefit from working together?	



**(F) Student Worksheet. Humans to Mars Mission Concept**

NAME: \_\_\_\_\_

**1. Congratulations. You've just been selected to be part of a team that designs the human mission to Mars! This mission is daring, and will require the skills and talent of many people.**

**Human Aspiration:  
Our human mission to Mars will seek answers to the following science questions:**

**Human Innovations:  
Engineering and Technology Tools we imagine will be needed to answer these questions:**

1.	
2.	
3.	
4.	
5.	

**2. Compare your team's ideas to those of other teams. What ideas were similar? What ideas did you appreciate from other teams that your team didn't think of?**

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**(G) Teacher Resource. Mars Mission Facts**

**Fly-bys:**

**Mariner 4, 6, and 7**

<http://mars.jpl.nasa.gov/missions/past/mariner3-4.html>

<http://mars.jpl.nasa.gov/missions/past/mariner6-7.html>

**Orbiters:**

**Mariner 9**

<http://mars.jpl.nasa.gov/missions/past/mariner8-9.html>

**Viking 1 and 2**

<http://mars.jpl.nasa.gov/missions/past/viking.html>

**Mars Global Surveyor**

<http://mars.jpl.nasa.gov/missions/past/globalsurveyor.html>

**Mars Odyssey Orbiter**

<http://mars.jpl.nasa.gov/missions/present/odyssey.html>

**Mars Reconnaissance Orbiter**

<http://mars.jpl.nasa.gov/programmissions/missions/present/2005/>

**Landers / Rovers:**

**Viking 1 and 2**

<http://mars.jpl.nasa.gov/missions/past/viking.html>

**Mars Pathfinder and the Sojourner Rover**

<http://mars.jpl.nasa.gov/missions/past/pathfinder.html>

**Mars Exploration Rovers (Spirit and Opportunity)**

<http://mars.jpl.nasa.gov/missions/present/2003.html>

**Phoenix Lander**

<http://mars.jpl.nasa.gov/missions/past/phoenix.html>

**Mars Science Laboratory and the Curiosity Rover**

<http://mars.jpl.nasa.gov/missions/present/msl.html>



### (H) Teacher Resource. Strange New Planet Rubric (1 of 3)

You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

**Instructional Objective 1: To produce a concept for an investigation that requires science questions, engineering and technological solutions, and teamwork.”**

**Related Standard(s)** (will be replaced when new NRC Framework-based science standards are released):

#### National Science Education Standards (NSES)

##### (A) Science as Inquiry: Abilities Necessary to Do Scientific Inquiry

Ask a question about objects, organisms, and events in the environment (Grades K-4: A1a).

Identify questions that can be answered through scientific investigations (Grades 5-8: A1a).

#### National Science Education Standards (NSES)

##### (A) Science as Inquiry: Understandings about Scientific Inquiry

Scientific investigations involve asking and answering a question and comparing the answer to what scientists already know about the world (Grades K-4: A2a).

Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models (Grades 5-8: A2a).

#### Related Rubrics for the Assessment of Learning Outcomes Associated with the Above Standard(s):

Learning Outcome	Expert	Proficient	Intermediate	Beginner
<b>LO1a: to generate science questions and answers</b>	Questions and answers are complete and thoughtful.	Questions and answers are complete.	Questions and answers are mostly complete.	Questions and answers are not complete.



### (H) Teacher Resource. Strange New Planet Rubric (2 of 3)

**Related Standards** (will be replaced when new NRC Framework-based science standards are released):

#### National Science Education Standards (NSES)

##### (E) Science and Technology: Understandings About Science & Technology

People have always had questions about their world. Science is one way of answering questions and explaining the natural world. (Grades K-4: E1a)

People have always had problems and invented tools and techniques (ways of doing something) to solve problems....(partial) (Grades K-4: E1b)

Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things they could not otherwise see, measure, and do. (Grades K-4: E1e)

Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations....(partial) (Grades 5-8: E1a)

Scientific and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis. (Grades 5-8: E1c)

#### Related Rubrics for the Assessment of Learning Outcomes Associated with the Above Standard(s):

Learning Outcome	Expert	Proficient	Intermediate	Beginner
<b>LO1b: to explain how different types of engineering and technological solutions help answer different science question</b>	Explanation is complex and thoughtful.	Explanation is thoughtful.	Explanation is somewhat thoughtful.	Explanation is basic.



### (H) Teacher Resource. Strange New Planet Rubric (3 of 3)

#### National Science Education Standards (NSES)

##### (E) Science and Technology: Understandings About Science & Technology

Scientists and engineers often work in teams with different individuals doing different things that contribute to results. This understanding focuses primarily on teams working together and secondarily on the combination of science and engineering teams. (Grades K-4: E1c)

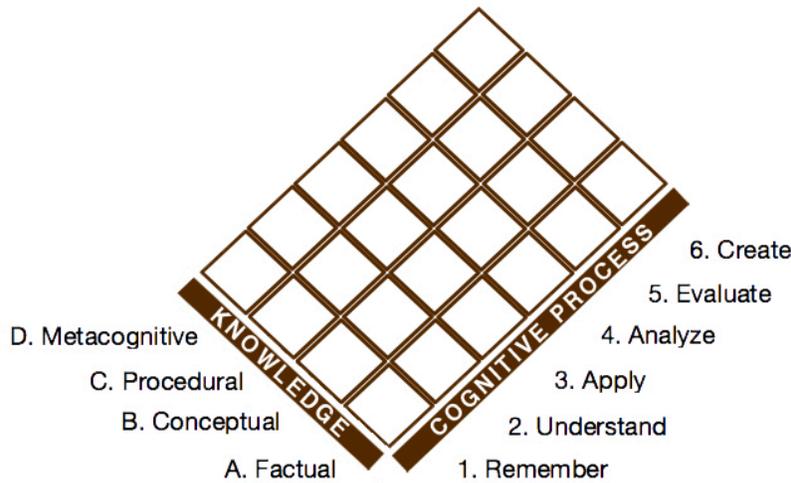
Women and men of all ages, backgrounds, and groups engage in a variety of scientific and technological work. (Grades K-4: E1c)

Many different people in different cultures have made and continue to make contributions to science and technology. (Grades 5-8: E1b)

Learning Outcome	Expert	Proficient	Intermediate	Beginner
<b>LO1c to explain the advantages of working in teams</b>	Explanation of advantages shows a high level of respect for the contributions of others.	Explanation of advantages shows respect for the contributions of others.	Explanation of advantages shows some respect for the contributions of others.	Explanation of advantages shows little respect for the contributions of others.



**(I) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (1 of 3)**



This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s). Activity procedures and assessments are designed to support the target knowledge/cognitive process.

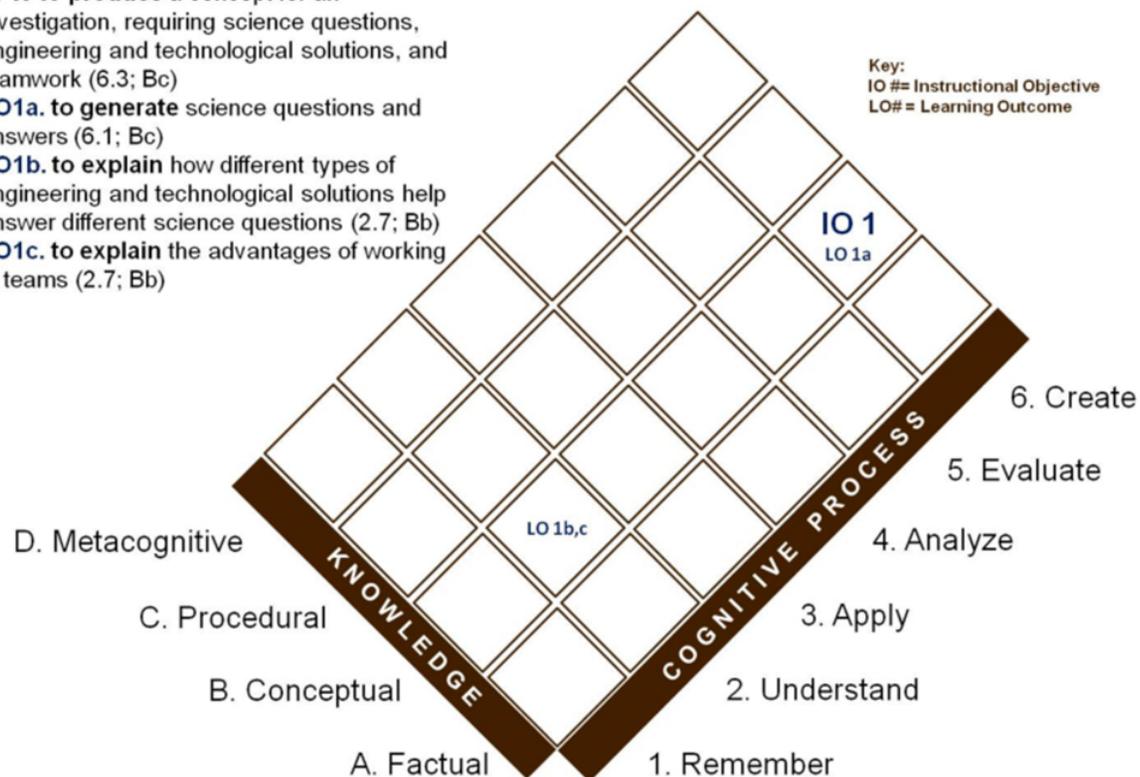
Knowledge	Cognitive Process
<p><b>A. Factual</b></p> <p><b>Aa:</b> Knowledge of Terminology</p> <p><b>Ab:</b> Knowledge of Specific Details &amp; Elements</p> <p><b>B. Conceptual</b></p> <p><b>Ba:</b> Knowledge of classifications and categories</p> <p><b>Bb:</b> Knowledge of principles and generalizations</p> <p><b>Bc:</b> Knowledge of theories, models, and structures</p> <p><b>C. Procedural</b></p> <p><b>Ca:</b> Knowledge of subject-specific skills and algorithms</p> <p><b>Cb:</b> Knowledge of subject-specific techniques and methods</p> <p><b>Cc:</b> Knowledge of criteria for determining when to use appropriate procedures</p> <p><b>D. Metacognitive</b></p> <p><b>Da:</b> Strategic Knowledge</p> <p><b>Db:</b> Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge</p> <p><b>Dc:</b> Self-knowledge</p>	<p><b>1. Remember</b></p> <p><b>1.1</b> Recognizing (Identifying)</p> <p><b>1.2</b> Recalling (Retrieving)</p> <p><b>2. Understand</b></p> <p><b>2.1</b> Interpreting (Clarifying, Paraphrasing, Representing, Translating)</p> <p><b>2.2</b> Exemplifying (Illustrating, Instantiating)</p> <p><b>2.3</b> Classifying (Categorizing, Subsuming)</p> <p><b>2.4</b> Summarizing (Abstracting, Generalizing)</p> <p><b>2.5</b> Inferring (Concluding, Extrapolating, Interpolating, Predicting)</p> <p><b>2.6</b> Comparing (Contrasting, Mapping, Matching)</p> <p><b>2.7</b> Explaining (Constructing models)</p> <p><b>3. Apply</b></p> <p><b>3.1</b> Executing (Carrying out)</p> <p><b>3.2</b> Implementing (Using)</p> <p><b>4. Analyze</b></p> <p><b>4.1</b> Differentiating (Discriminating, distinguishing, focusing, selecting)</p> <p><b>4.2</b> Organizing (Finding coherence, integrating, outlining, parsing, structuring)</p> <p><b>4.3</b> Attributing (Deconstructing)</p> <p><b>5. Evaluate</b></p> <p><b>5.1</b> Checking (Coordinating, Detecting, Monitoring, Testing)</p> <p><b>5.2</b> Critiquing (Judging)</p> <p><b>6. Create</b></p> <p><b>6.1</b> Generating (Hypothesizing)</p> <p><b>6.2</b> Planning (Designing)</p> <p><b>6.3</b> Producing (Constructing)</p>



### (I) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Pedagogically, it is important to ensure that objectives and outcomes are written to match the knowledge and cognitive process students are intended to acquire.

**IO1:** to produce a concept for an investigation, requiring science questions, engineering and technological solutions, and teamwork (6.3; Bc)  
**LO1a.** to generate science questions and answers (6.1; Bc)  
**LO1b.** to explain how different types of engineering and technological solutions help answer different science questions (2.7; Bb)  
**LO1c.** to explain the advantages of working in teams (2.7; Bb)





### (I) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (3 of 3)

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Below are the knowledge and cognitive process types students are intended to acquire per the instructional objective(s) and learning outcomes written for this lesson. The specific, scaffolded 5E steps in this lesson (see 5.0 Procedures) and the formative assessments (worksheets in the Student Guide and rubrics in the Teacher Guide) are written to support those objective(s) and learning outcomes. Refer to (I, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (I, 2 of 3) provides a visual description of the placement of learning outcomes that enable the overall instructional objective(s) to be met.

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#### At the end of the lesson, students will be able

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#### **IO1: to produce a simple concept...**

**6.3:** to produce

**Bc:** knowledge of theories, models, and structures

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#### To meet that instructional objective, students will demonstrate the abilities:

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#### **LO1a: to generate science questions and answers**

6.1: to generate

Bc: knowledge of theories, models, and structures

#### **LO1b: to explain types of solutions...**

2.7: to explain

Bb: knowledge of principles and generalizations

#### **LO1c: to explain advantages...**

2.7: to explain

Bb: knowledge of principles and generalizations