Follow Your Curiosity: A 2012 NASA Summer of Innovation Collection

Lesson 2

Earth, Earth's Moon, Mars Balloons

Grades: K-8 Prep Time: ~10 Minutes Lesson Time: 75 Mins

WHAT STUDENTS DO: Construct a Planetary Model

Curiosity about our place in space and whether we can travel to distant worlds beyond our own depends upon understanding the size, distance, and other characteristics of moons and planets in our solar system. For this activity, students will construct a balloon scale model to understand the relative sizes of the Earth, Earth's Moon and Mars in relation to each other and their relative distance to each other at this scale. They will use this model to predict distances and reflect on how scientists use models to construct explanations through the scientific process. In this collection, this activity introduces the concept of models, which will be built upon in subsequent lessons, as well as the first set of Earth/Mars comparisons.

NRC CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES
WHAT IS THE UNIVERSE & WHAT IS EARTH'S PLACE IN IT? *NRC Core Question: ESS1: Earth's Place in the Universe*	*Students will be able*
What are the predictable patterns caused by Earth's movement in the solar system? *NRC ESS1.B: Earth & the Solar System*	**IO1: to construct** a simple model

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:

- Each student will need a single balloon in one of three colors: blue (Earth), red (Mars) or white (Earth's Moon). For example, for a class of 30 students, you would need 30 balloons total: 10 blue, 10 red, 10 white.
- 10 Cloth Tape Measures (or meter sticks and pieces of string)
- 10 Calculators
- LCD projector and computer with access to internet
- Access to images on the following websites:
  - http://hirise.lpl.arizona.edu/earthmoon.php
  - http://marsrovers.jpl.nasa.gov/gallery/press/spirit/20040311a/11-ml-02-earth-A067R1_br.jpg

Please Print:

From Student Guide

(A) Earth, Earth's Moon, Mars Comparison – 1 per student
(B) Relative Size & Distance Sheet – 1 per student
(C) Student Reflection – 1 per student

Optional Materials

From Teacher Guide

(D) "Earth, Earth's Moon, Mars Balloons" Assessment Rubrics
(E) Alignment of Instructional Objective(s) and Learning Outcome(s) with Knowledge and Cognitive Process Types

3.0 Vocabulary

Models a simulation that helps explain natural and human-made systems and shows possible flaws

Prediction the use of knowledge to identify and explain observations or changes in advance (NSES, 1996)

Relative Distance how far away objects are when compared to one another

Relative Size how large objects are when compared to one another

Relationship a connection among and between objects

Scale a measurement that will represent a standard measurement for comparison among objects

4.0 Instructional Objectives, Learning Outcomes, & Standards

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:

WHAT IS THE UNIVERSE & WHAT IS EARTH'S PLACE IN IT?

NRC Core Question: ESS1: Earth's Place in the Universe

What are the predictable patterns caused by Earth's movement in the solar system?

NRC ESS1.B: Earth & the Solar System

Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*	
IO1: **to construct** a simple model	**LO1a. to compare** the relative size and distance of the Earth, Earth's Moon, and Mars **LO1b. to use** a calculated scale for establishing relative distances **LO1c. to predict** using a model **LO1d. to explain** scientific processes (scale, use of models)	**NSES: UNIFYING CONCEPTS & PROCESSES:** **K-12: (A2) Evidence, models, and explanations** **NSES (D): EARTH & SPACE SCIENCES:** **Earth in the Solar System** **Grades 5-8:** E3a	***Rubrics in Teacher Guide***

This activity also aligns with:

NRC SCIENCE & ENGINEERING PRACTICES

2) Developing and using models
5) Using mathematical and computational thinking

NRC SCIENCE & ENGINEERING CROSSCUTTING CONCEPTS

4) Systems and system models

21ST CENTURY SKILLS

- Critical Thinking and Problem Solving
- Communication
- Collaboration

5.0 Procedure

PREPARATION (~10 minutes)

A. Print handouts (A), (B), and (C) for each student.
B. Access pictures online

STEP 1: ENGAGE (~10 minutes)
Exploring Sizes of Planets

A. Using *(A) Earth, Earth's Moon, Mars Comparison* worksheet, ask students to make a prediction using a drawing of the Earth, Earth's Moon, and Mars, showing what they think the sizes are in relationship to each other.

B. Look at the image of Earth and Earth's Moon from the Mars perspective (http://hirise.lpl.arizona.edu/earthmoon.php) from an image taken from a spacecraft orbiting Mars. Discuss the size of the Earth and Earth's Moon in relationship to each other and from representations in books, charts, and other materials. Does it look like the Earth and Earth's Moon are the same size?

C. Look at the image of Earth from the surface of Mars. (http://marsrovers.jpl.nasa.gov/gallery/press/spirit/20040311a/11-ml-02-earth-A067R1_br.jpg).

STEP 2: EXPLORE (~15 minutes)
Representing planetary objects with a simple model.

A. Discuss how people use models to represent ideas or objects. Point out that scientists and engineers create models to understand an idea or object. Today, we will be making models of the Earth, Earth's Moon, and Mars to represent their sizes and distances to scale.

B. Distribute blue balloons to 1/3 of the class, red balloons to 1/3, and white balloons to the final 1/3. Explain that the three balloons represent the Earth (blue), Earth's Moon (white), and Mars (red).

C. Group students in groups of 3, each with a different color balloon.

D. Ask the students with the blue balloon to blow their balloons up until it is 63 centimeters in circumference. You may need to demonstrate for the students how to measure the circumference using a cloth tape measure or a piece of string and a meter stick.

E. Once the balloon is the appropriate circumference, ask the students to tie off the balloon. This balloon will represent Earth.

F. Ask the students to fill in *(B) Relative Size and Distance Sheet* with the circumference of Earth.

G. Students will now predict the relative circumferences of Earth's Moon and Mars based on the size of Earth and record that circumference prediction on the *(B) Relative Size and Distance Sheet* in the "Balloon Circumference Prediction" column.

H. Explain to students that the scale for this model is 63,800,000 times smaller than the real thing. Ask students to multiply the balloon circumference (63 cm) X 63,800,000 (scale factor) to find the actual diameter of Earth (4,019,400,000 cm or 40,194 km).

I. To find the "Actual Balloon Circumferences" for Earth's Moon and Mars, the circumferences have been provided for both. The students will need to divide these by 63,800,000. They should find the model of Earth's Moon is 17 cm and of Mars is 33 cm.

Differentiation Tip: Students may then convert centimeters to kilometers.

J. Students should now inflate Earth's Moon and Mars balloon to the appropriate sizes and tie them off.

STEP 3: EXPLAIN (~5 minutes)

Explaining scale in a model.

A. Discuss the idea of scale with students. Point out that it is obvious that the planets and moons are not as small as the balloons, but because we calculated them using a scale, the sizes represent the bodies in relationship to each other. Therefore, the Earth can be estimated as twice as big as Mars, and 4 times bigger than Earth's Moon.

STEP 4: ELABORATE (~15 minutes)

Using a model to make predictions.

A. Ask students to now make a prediction regarding the relative distances between Earth, Earth's Moon, and Mars.

B. They should stand as a group, arranging themselves based on their beliefs about the relative distances and measure these distances. These measurements will represent their prediction, to be completed on the *(B) Relative Size and Distance Sheet*.

C. Student will use their new understanding of scale to calculate the relative distances of the Earth, Earth's Moon, and Mars. They will continue to use the 63,800,000-scale model.

D. Once students have calculated the scaled differences, ask them to begin arranging themselves into the appropriate distances.

E. Eventually a student will say they need to step out of the room to get to Mars. This moment is a great time to mention that the distance to Mars is so great that, if we were to place it correctly according to this scale, it would actually be ¾ of a mile or 1.21km away. As a frame of reference for how far that is, provide a visual cue of a familiar neighborhood location recognizable by the students that is about ¾ of a mile from the school.

F. Discuss with the students the amount of time it would take us to travel to Earth's Moon and Mars. Typically, it takes 2 - 3 days to reach Earth's Moon using a rocket-powered vessel, while it would take approximately 6-11 months to reach Mars with robotic spacecraft, depending on where the Earth and Mars are in their orbits at the time of launch.

Differentiation Tip: Ask students to convert cm to km and/or use scientific notation for the planet distances.

STEP 5: EVALUATE (~20 minutes)

Reflecting metacognitively on the use of modeling in the scientific process

A. Ask students to complete the *(C) Student Reflection Sheet.*

6.0 Extensions

Explore the relative size and distance of the moons of Mars or other planets in our solar system.

7.0 Evaluation/Assessment

Use the student sheets as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The checklist evaluates the activities using the National Science Education Standards.

8.0 References

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