Earth, Earth's Moon, Mars Balloons

5th Grade NGSS, Common Core, and 21st Century Skills Alignment Document

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 model** the Earth, Earth's Moon, and Mars system

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.

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. The 5E stages can be cyclical and iterative.

2.0 Instructional Objectives, Learning Outcomes, & Standards

Instructional objectives and learning outcomes are aligned with

- National Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)'s, *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and* Technical Subjects
- Partnership for 21st Century Skills, *A Framework for 21st Century Learning*

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

- Your **instructional objectives (IO)** for this lesson align with the NGSS Framework and NGSS.
- 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

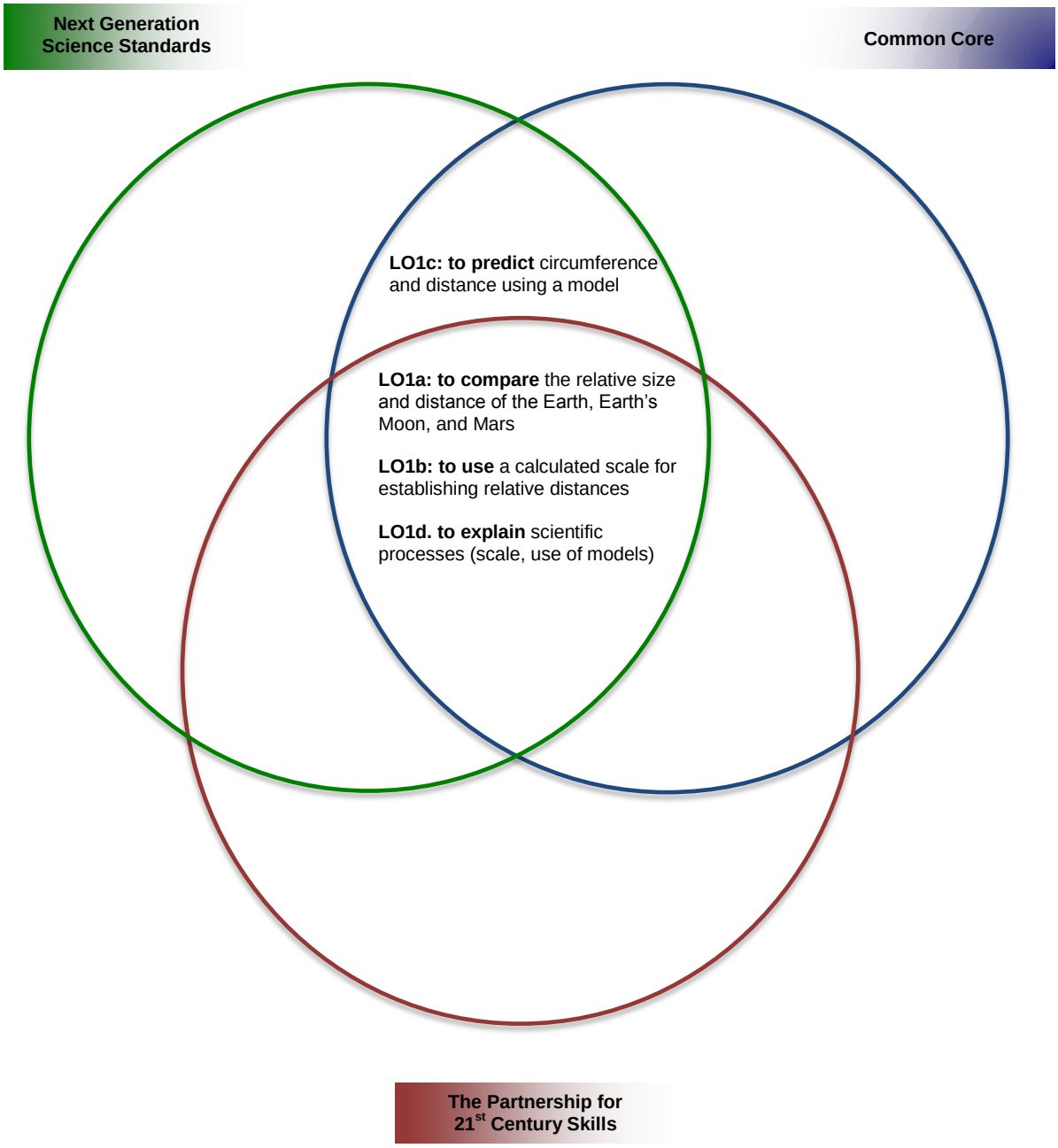
What are the predictable patterns caused by Earth's movement in the solar system?

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 model** the Earth, Earth's Moon, and Mars system	**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** circumference and distance using a model **LO1d. to explain** scientific processes (scale, use of models)	**NSES: UNIFYING CONCEPTS & PROCESSES:** **K-12: (A2) Evidence, models, and explanations** **NGSS Practices:** **Developing and Using Models** **Planning and Carrying out Investigations** **Analyzing and Interpreting Data** **Using Mathematics and Computational Thinking** **Scientific Knowledge is Based on Empirical Evidence** **Science Models, laws, Mechanisms, and theories Explain natural Phenomena** **NGSS Cross-Cutting Concept:** **Scale, Proportion and Quantity**

3.0 Learning Outcomes, NGSS, Common Core, & 21st Century Skills Connections

The connections diagram is used to organize the learning outcomes addressed in the lesson to establish where each will meet the Next Generation Science Standards, ELA Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents.



4.0 Evaluation/Assessment

Rubric*:* A rubric has been provided to assess student understanding of the simulation and to assess metacognition. A copy has been provided in the Student Guide for students to reference prior to the simulation. This rubric will allow them to understand the expectations set before them.

5.0 References

Achieve, Inc. (2013). *Next generation science standards*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.

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.

Miller, Linn, & Gronlund. (2009). *Measurement and assessment in teaching*. Upper Saddle River, NJ: Pearson.

National Academies Press. (1996, January 1). *National science education standards*. Retrieved February 7, 2011 from http://www.nap.edu/catalog.php?record_id=4962

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washington, DC: Authors.

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 21st Century Skills (2011). *A framework for 21st century learning.* Retrieved March 15, 2012 from http://www.p21.org

(L) Teacher Resource. Earth, Earth's Moon, Mars Balloons 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 model the Earth, Earth's Moon, and Mars system

Related Standard(s)

National Science Education Standards (NSES)
UNIFYING CONCEPTS & PROCESSES

Grades K-12 (A2) Evidence, models, and explanations
Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. Different terms, such as "hypothesis," "model," "law," "principle," "theory," and "paradigm" are used to describe various types of scientific explanations.

As students develop and as they understand more science concepts and processes, their explanations should become more sophisticated. That is, their scientific explanations should more frequently include a rich scientific knowledge base, evidence of logic, higher levels of analysis, greater tolerance of criticism and uncertainty, and a clearer demonstration of the relationship between logic, evidence, and current knowledge.

Next Generation Science Standards (NGSS)
Practices: Developing and Using Models
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Develop and/or use models to describe and/or predict phenomena. (Grades 3-5)
- Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. (Grades 3-5)

Next Generation Science Standards (NGSS)
Practices: Planning and Carrying out Investigations
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Evaluate appropriate methods and/or tools for collecting data. (Grades 3-5)
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (Grades 3-5)

Next Generation Science Standards (NGSS)
Practices: Analyzing and Interpreting Data
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. (Grades 3-5)
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. (Grades 3-5)

Next Generation Science Standards (NGSS)
Practices: Using Mathematics and Computational Thinking
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. (Grades 3-5)

Next Generation Science Standards (NGSS)
Practices: Scientific Knowledge is Based on Empirical Evidence
(Learning Outcomes Addressed: LO1a, LO1b)

- Scientists use tools and technologies to make accurate measurements and observations. (Grades 3-5)

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Scale, Proportion and Quantity
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume. (Grades 3-5)

Common Core State Standards
Speaking and Listening Standards: Comprehension and Collaboration
(Learning Outcomes Addressed: LO1a, LO1c, LO1d)

- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.
    - Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
    - Follow agreed-upon rules for discussions and carry out assigned roles.
    - Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
    - Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

Common Core State Standards
Mathematics – Numbers and Operations in Base Ten
(Learning Outcomes Addressed: LO1b)

- 5.NBT.1 Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.
- 5.NBT.2 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.
- 5.NBT.3 Read, write, and compare decimals to thousandths.
    - Read and write decimals to thousandths using base-ten numerals, number names, and expanded form, e.g., 347.392 = 3 × 100 + 4 × 10 + 7 × 1 + 3 × (1/10) + 9 × (1/100) + 2 × (1/1000).
    - Compare two decimals to thousandths based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.
- 5.NBT.4 Use place value understanding to round decimals to any place.
- 5.NBT.5 Fluently multiply multi-digit whole numbers using the standard algorithm.
- 5.NBT.6 Find whole-number quotients of whole numbers with up to four-digit dividends and two-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.

21st Century Skills
Collaboration
(Learning Outcomes Addressed: LO1a, LO1b, LO1d)

- Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning. (Grade 8 Benchmark)

(D) Teacher Resource. Earth, Earth's Moon, & Mars Balloons Rubric (2 of 2)

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

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: to compare the relative size and distance of the Earth, Earth's Moon, and Mars	Model is correctly refined from the prediction to reflect the appropriate size and distances of the bodies.	Model is refined from the prediction with a minimal amount of support from the facilitator.	Model is refined from the prediction with a fair amount of support from the facilitator.	Model reflects the predicted model from the beginning of the activity.
LO1b: to use a calculated scale for establishing relative distances	Calculations are accurate to relative scale distances and sizes and appropriate measuring tools are used.	Calculations are relatively accurate to scale distances and sizes and appropriate measuring tools are used.	Calculations are relatively accurate to scale distances and sizes and most measuring tools are appropriate to the task.	Calculations are made with a variety of tools.
LO1c: to predict circumference and distance using a model	Prediction is logical and based on evidence from prior examinations of the model planets. Predictions show insightful interpretation of the data.	Prediction is logical and based on evidence from prior examinations of the model planets.	Prediction is logical and uses some evidence from prior examinations of model planets.	Prediction is written and based on personal preferences.
LO1d: to explain scientific processes (scale, use of models)	Explanation discusses the use of models as a predictive and explanatory tool that scientists use to test/communicate scientific phenomena.	Explanation discusses the use of models as a predictive or explanatory tool that scientists use to test or communicate scientific phenomena.	Explanation discusses the use of models as an explanatory tool that scientists use to communicate scientific phenomena.	Explanation discusses use of models by scientists.

(L) Teacher Resource. Earth, Earth's Moon, Mars Balloons Rubric (2 of 3)

Partnership for 21st Century Skills

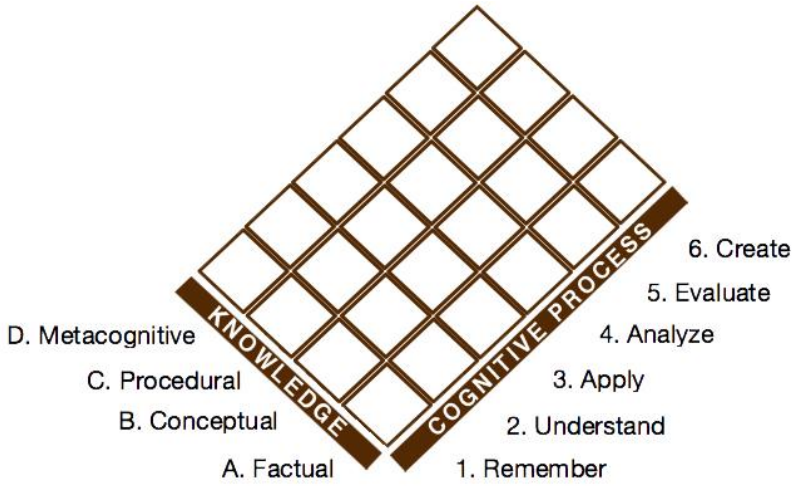
	Expert	Proficient	Intermediate	Beginner
Effectiveness of collaboration with team members and class.	Extremely Interested in collaborating in the simulation. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure everyone has a contribution.	Extremely Interested in collaborating in the simulation. Actively provides suggestions and occasionally listens to suggestions from others. Refines suggestions from others.	Interested in collaborating in the simulation. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the simulation.

(L) Teacher Resource. Earth, Earth's Moon, Mars Balloons Rubric (3 of 3)

Common Core – ELA

	Expert	Proficient	Intermediate	Beginner
Effective Demonstration of Comprehension and Collaboration	Clearly articulates ideas in collaborative discussion while following agreed upon class rules for discussion. Extremely prepared drawing from experiences. Asks clarifying questions to ensure full understanding of content. Articulates own ideas related to the discussion and connects others ideas to own.	Articulates ideas in collaborative discussion while following agreed upon class rules for discussion. Prepared for discussion by drawing from experiences. Asks questions. Articulates own ideas related to the discussion.	Interested in collaborative discussion. Asks questions. Articulates own ideas related to the discussion.	Interested in collaboration with peers.

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



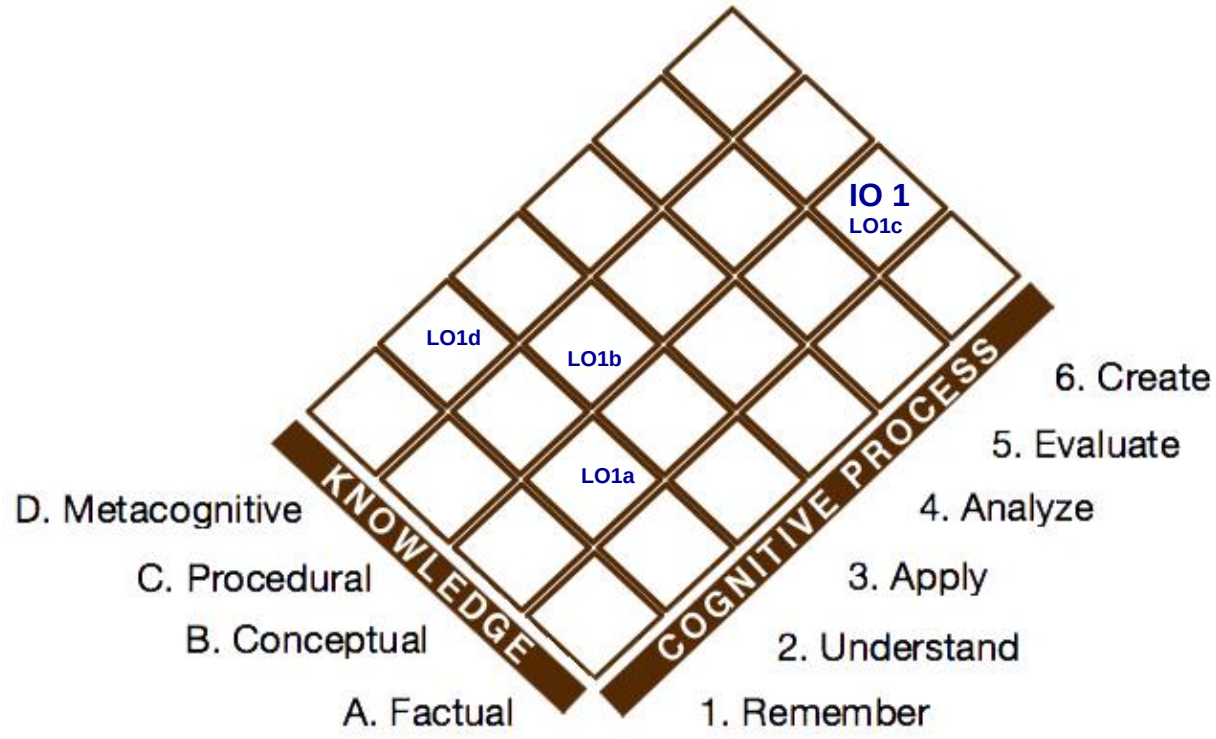
This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s).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

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

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

IO1: to model the Earth, Earth's Moon, and Mars system (6.3; Bc)

- **LO1a. to compare** the relative size and distance of the Earth, Earth's Moon, and Mars (2.6; Bc)
- **LO1b. to use** a calculated scale for establishing relative distances (3.1; Ca)
- **LO1c. to predict** circumference and distance using a model (6.1; Bb)
- **LO1d to explain** scientific processes (scale, use of models) (2.7; Da)



(M) 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 (M, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (M, 2 of 3) provides a visual description of the placement of learning outcomes that enable the overall instructional objective(s) to be met.

At the end of the lesson, students will be able

IO1: to construct a simple model
6.3: to construct
Bc: knowledge of theories, models, and structures

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

LO1a: to compare size/distance in model
2.6: to compare
Bc: knowledge of theories, models, and structures

LO1b: to use a calculated scale for establishing relative distances
3.1: to use
Ca: knowledge of subject-specific skills and algorithms

LO1c: to predict using a model
6.1: to predict
Bb: knowledge of principles and generalizations

LO1d: to explain scientific processes
2.7: to explain
Da: strategic knowledge