



Mystery Planet

Middle School NGSS, Common Core, and 21st Century Skills Alignment Document



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

In this activity, students step into the shoes of real planetary scientists and explore crustal samples from a “Mystery” planet. Using sorting/classification, students will interpret the geologic history of a region from which a sample has been collected and make inferences about past life or the potential for life on the “Mystery” planet.

NGSS CORE & COMPONENT QUESTIONS

HOW CAN ONE EXPLAIN THE STRUCTURE, PROPERTIES, AND INTERACTIONS OF MATTER?

NGSS Core Question: PS1: Matter and It's Interactions

How do particles combine to form the variety of matter one observes?

NGSS PS1.A: Structure and Properties of Matter

INSTRUCTIONAL OBJECTIVES

Students will be able

IO1: to model
scientific
classification
schemes through
identifying criteria
necessary to sort
and classify
materials and
relate them to the
geologic history of
a region



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:



HOW CAN ONE EXPLAIN THE STRUCTURE, PROPERTIES, AND INTERACTIONS OF MATTER?

NGSS Core Question: PS1: Matter and Its Interactions

How do particles combine to form the variety of matter one observes?

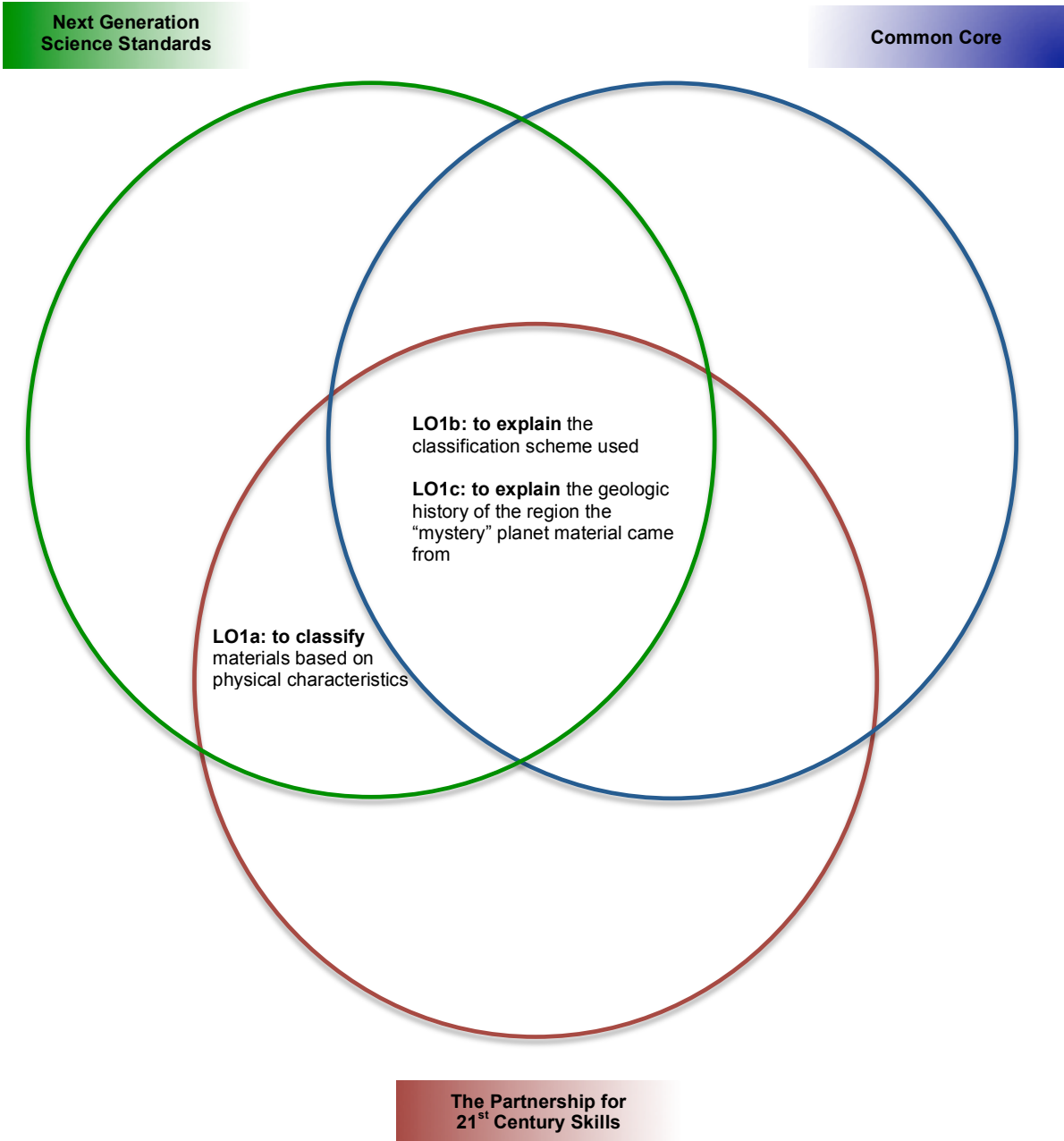
NGSS PS1.A: Structure and Properties of Matter

Instructional Objective <i>Students will be able</i>	Learning Outcomes <i>Students will demonstrate the measurable abilities</i>	Standards <i>Students will address</i>
<p>IO1:</p> <p>to model scientific classification schemes through identifying criteria necessary to sort and classify materials and relate them to the geologic history of a region</p>	<p>LO1a. to classify materials based on physical characteristics</p> <p>LO1b. to explain the classification scheme used</p> <p>LO1c. to explain the geologic history of the region the “mystery” planet material came from</p>	<p>NSES (B): PHYSICAL SCIENCE: Properties of Objects and Materials Grades 5-8: B1a</p> <p>NSES (D): EARTH AND SPACE SCIENCE: Structure of the Earth System Grades 5-8: D1d, D1e Earth’s History Grades 5-8: D2a, D2b</p> <p>NGSS Disciplinary Core Idea: PS1.A: Structure and Properties of Matter</p> <p>NGSS Practices: Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Scientific Knowledge is Based on Empirical Evidence</p> <p>NGSS Cross-Cutting Concept: Patterns Systems and System Models Science is a Way of Knowing Scientific Knowledge Assumes an Order and Consistency in Natural Systems</p>



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>

Additional information about obtaining prepared "Mystery" Planet crustal material sample packets can be obtained from the author by writing, to D. Louis Finsand, Spectrum House, 1501 W. 19th St. Cedar Falls, Iowa, 50613, Phone: (319) 273-2760.

**(L) Teacher Resource. Mystery 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 model scientific classification schemes through identifying criteria necessary to sort and classify materials and relate them to the geologic history of a region.

Related Standard(s)**National Science Education Standards (NSES)****(B) Physical Science: Properties of Objects and Materials**

A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties (Grades 5-8: B1a).

National Science Education Standards (NSES)**(D) Earth and Space Science: Structure of the Earth System**

Some changes in the solid earth can be described as the “rock cycle.” Old rocks at the earth’s surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues (Grades 5-8: D1d).

Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture (Grades 5-8: D1e).

National Science Education Standards (NSES)**(D) Earth and Space Science: Earth’s History**

The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet (Grades 5-8: D2a).

Fossils provide important evidence of how life and environmental conditions have changed (Grades 5-8: D2b).



This lesson supports the preparation of students toward achieving Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below:

(MS-PS1-2),(MS-PS1-3)



Next Generation Science Standards (NGSS)

Practices: Developing and Using Models

(Learning Outcomes Addressed: LO1a, LO1b)

- Develop a model to describe unobservable mechanisms.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.



Next Generation Science Standards (NGSS)

Practices: Planning and Carrying out Investigations

(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.



Next Generation Science Standards (NGSS)

Practices: Analyzing and Interpreting Data

(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Analyze and interpret data to provide evidence for phenomena.
- Analyze and interpret data to determine similarities and differences in findings.



Next Generation Science Standards (NGSS)

Practices: Constructing Explanations and Designing Solutions

(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- Construct an explanation using models or representations.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.



Next Generation Science Standards (NGSS)

Practices: Scientific Knowledge is Based on Empirical Evidence

(Learning Outcomes Addressed: LO1a, LO1b)

- Science knowledge is based upon logical and conceptual connections between evidence and explanations.



**Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Patterns**

(Learning Outcomes Addressed: LO1a, LO1b)

- Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.



**Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Systems and System Models**

(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.



**Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Science is a Way of Knowing**

(Learning Outcomes Addressed: LO1b, LO1c)

- Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.
- Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge.
- Science is a way of knowing used by many people, not just scientists.



**Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

(Learning Outcomes Addressed: LO1b, LO1c)

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
- Science carefully considers and evaluates anomalies in data and evidence.



**Next Generation Science Standards (NGSS)
Disciplinary Core Idea: PS1.A: Structure and Properties of Matter**

(Learning Outcomes Addressed: LO1a, LO1b)



- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.



21st Century Skills

Creativity and Innovation

(Learning Outcomes Addressed: LO1b)

- Students are able to describe how science and engineering involve creative processes that include generating and testing ideas, making observations, and formulating explanations; and can apply these processes in their own investigations. (Grade 8 Benchmark)



21st Century Skills

Collaboration

(Learning Outcomes Addressed: LO1a, LO1b)

- 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)



21st Century Skills

Social and Cross-Cultural Skills

(Learning Outcomes Addressed: LO1a, LO1b)

- Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives. (Grade 8 Benchmark)

**(L) Teacher Resource. Mystery Planet Rubric (1 of 3)****Learning Outcomes Assessment:**

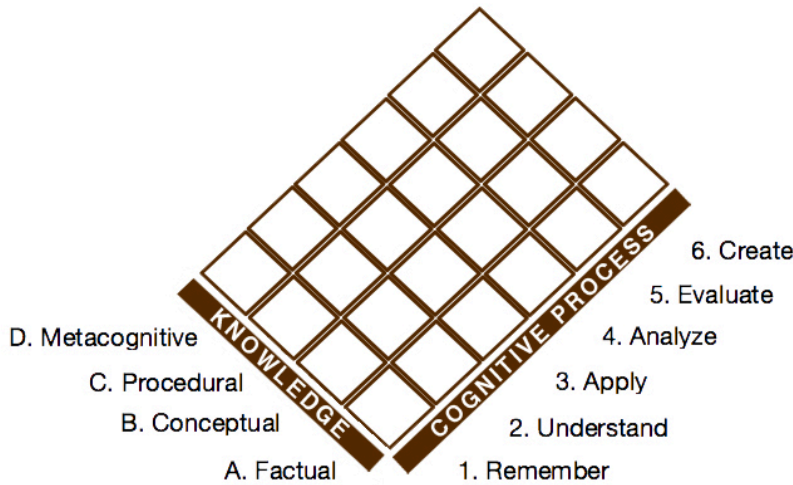
	Expert	Proficient	Intermediate	Beginner
LO1a: to classify materials based on physical characteristics	Classified materials demonstrate organization and appropriate groupings.	Classified materials are well organized.	Classified materials have a reasonable classification scheme.	Classification scheme is difficult to determine.
LO1b: to explain the classification scheme used	Explanation is complex and thoughtful.	Explanation is thoughtful.	Explanation is somewhat thoughtful.	Explanation is basic.
LO1c: to explain the geologic history of the region the “mystery” planet material came from	Explanation is complex and thoughtful and uses geology concepts at a high level of understanding.	Explanation is thoughtful and uses an understanding of geology concepts.	Explanation is somewhat thoughtful and uses a basic understanding of geology concepts.	Explanation is basic and has a lack of understanding of geology concepts..

**(L) Teacher Resource. Mystery Planet Rubric (2 of 3)****Partnership for 21st Century Skills**

	Expert	Proficient	Intermediate	Beginner
Effectiveness of Creativity and Innovation	Model is an excellent representation of a wide variety of generating and testing of ideas to achieve equilibrium while acquiring high science return.	Model is an excellent representation of a wide variety of generating and testing of ideas to achieve equilibrium while acquiring moderate science return.	Model is a representation of a variety of generating and testing of ideas to achieve equilibrium while acquiring moderate science return.	Model is a representation of generating and testing of ideas to attempt to achieve equilibrium while acquiring at least one science return.
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.
Effectiveness in communication	Communicates ideas in a clearly organized and logical manner that is consistently maintained.	Communicates ideas in an organized manner that is consistently maintained.	Communications of ideas are organized, but not consistently maintained.	Communicates ideas as they come to mind.



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



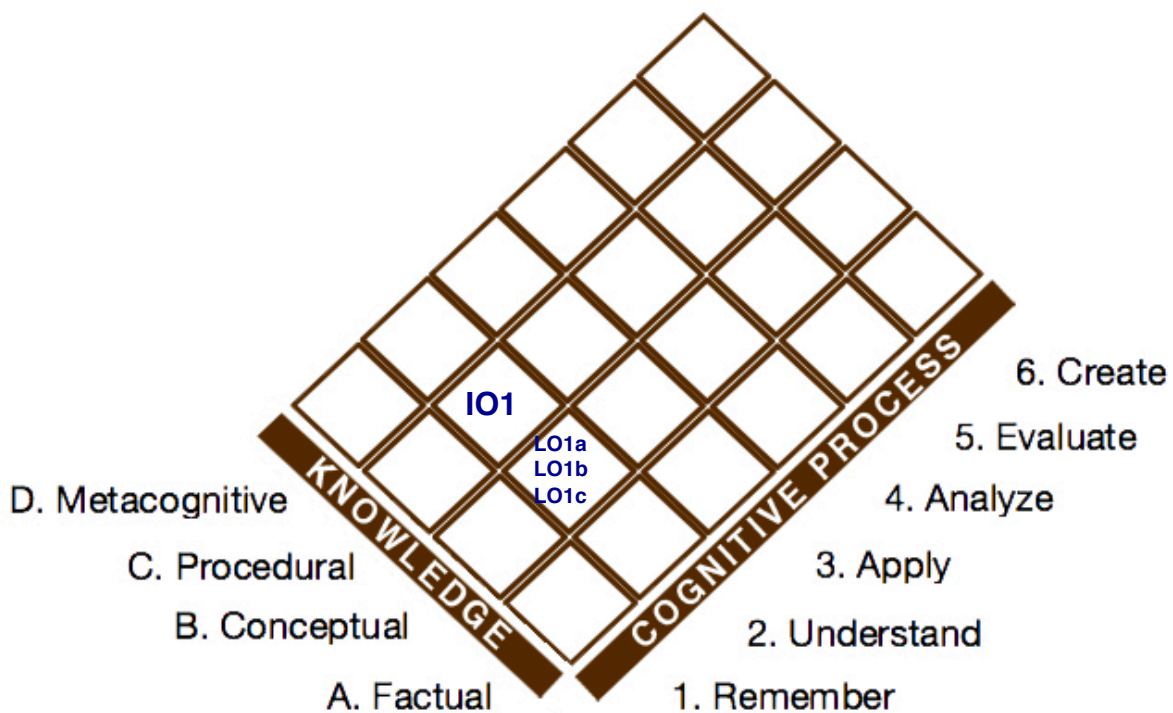
This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s).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

- IO 1:** to model scientific classification schemes through identifying criteria necessary to sort and classify materials and relate them to the geologic history of a region (2.7; Cb)
LO1a: to classify materials based on physical characteristics (2.3; Ba)
LO1b: to explain the classification scheme used (2.7; Ba)
LO1c: to explain the geologic history of the region the “mystery” planet material came from (2.7; Bb)



**(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 model scientific classification schemes through identifying criteria necessary to sort and classify materials and relate them to the geologic history of a region (2.7; Cb)

2.7: to explain

Cb: Knowledge of subject-specific techniques and methods

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

LO1a: to classify materials based on physical characteristics

2.3: to classify

Ba: knowledge of classifications and categories

LO1b: to explain the classification scheme used

2.7: to explain

Ba: knowledge of classifications and categories

LO1c: to explain the geologic history of the region the "mystery" planet material came from

2.7: to explain

Bb: knowledge of principles and generalizations