Mystery Planet

Grades: K-8 Prep Time: ~10 Minutes Lesson Time: ~90 Minutes

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.

NRC CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES
WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT? *NRC Core Question: ESS1: Earth and Space Science*	*Students will be able*
HOW AND WHY IS EARTH CONSTANTLY CHANGING *NRC Core Question: ESS2: Earth and Space Science*	
How do people reconstruct and date events in Earth's planetary history? *NRC Component Question: ESS1C: The History of Planet Earth* **How do Earth's major systems interact?** *NRC Component Question: ESS2A: Earth Materials and Systems*	**IO1: to identify** 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. 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:

"Mystery" Planet Crustal Material bags (1 per pair of students)

- Coarse and fine sand (playground, river, or beach)
- Small rounded "pea" gravel pebbles (stream or gravel pit)
- Small flat "skipper" type round, round, flat, pebbles (rocky lake or ocean beach)
- Angular crushed stone (rural road, driveway, concrete, or cement mixing plant)
- Table salt
- Coarse rock salt (sidewalk melting salt or crushed water softener pellets)
- Crushed clinkers from a coal furnace
- Vermiculite or pearlite (garden shop)
- Small fossil fragments (broken shells)
- Add any other rocky planet, rock fragments or synthetic materials that meet classroom needs – Make sure materials are sterile and free of bacteria
- Small, heavy duty zipper bag

For observing and sorting crustal materials (1 per pair of students)

- Hand lens
- Popsicle sticks
- Tweezers (plastic for younger students)
- Magnet (Cut up refrigerator magnets will do)
- Tray (Dissection, foam, or cafeteria tray will do)

Please Print:

From Student Guide:

(A) Sorting Graph Paper – 1 per pair of students
(B) Classification Sheet – 1 per student
(C) Concept Mapping Sheet – 1 per student

Optional Materials

From Teacher Guide:

(D) "Mystery Planet" Assessment Rubrics
(E) Placement of Instructional Objectives and Learning Outcomes in Taxonomy

3.0 Vocabulary

Classification	a grouping assigned to materials based on common characteristics
Compounds	composed of two or more elements
Deposition	material that is deposited or dropped from water or air
Element	a substance that cannot be separated into a simpler substance
Erosion	movement of material by water, wind or ice
Geologic History	an explanation of all of the geologic processes that have occurred in a region based on empirical evidence
Inferences	using logic and empirical evidence to establish a conclusion
Mixtures	a blend of elements and compounds
Observations	specific details recorded to describe an object
Physical Properties	distinctive characteristics or qualities that are observable
Rock Cycle	process used to describe changes to rock over time due to melting, cooling, erosion, weathering, heat, and pressure
Sedimentation	The deposition or accumulation of sediment
Weathering	mechanical and chemical processes that cause exposed rock to decompose.

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:

WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT?

NRC Core Question: ESS1: Earth and Space Science

HOW AND WHY IS EARTH CONSTANTLY CHANGING

NRC Core Question: ESS2: Earth and Space Science

How do people reconstruct and date events in Earth's planetary history?

NRC Component Question: ESS1C: The History of Planet Earth

How do Earth's major systems interact?

NRC Component Question: ESS2A: Earth Materials and Systems

Crosscutting Concepts:

Patterns
Cause and Effect
Energy and Matter

Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*	
IO1: **to identify** criteria necessary to sort and classify materials and relate them to the geologic history of a region	**LO1a: to classify** materials based on physical characteristics **LO1b. to explain** the classification scheme used **LO1c. to explain** the geologic history of the region the "mystery" planet material came from	**NSES (B): PHYSICAL SCIENCE:** **Properties of Objects and Materials** **Grades K-4:** B1a, B1b, B1c **Grades 5-8:** B1a **NSES (D): EARTH AND SPACE SCIENCE:** **Properties of Earth Materials** **Grades K-4:** D1a, D1b, D1c **Changes in the Earth and Sky** **Grades K-4:** D3a **Structure of the Earth System** **Grades 5-8: D1d, D1e** **Earth's History** **Grades 5-8: D2a, D2b**	***Rubrics in Teacher Guide***

This activity also aligns with:

21ST CENTURY SKILLS

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

5.0 Procedures

PREPARATION (~45 minutes)

Preparing the "Mystery" Planet Crustal Material bags

A. Create a mixture of the following materials:

- Coarse and fine sand (playground, river, or beach)
- Small rounded "pea" gravel pebbles (stream or gravel pit)
- Small flat "skipper" type round, round, flat, pebbles (rocky lake or ocean beach)
- Angular crushed stone (rural road, driveway, concrete, or cement mixing plant)
- Table salt
- Coarse rock salt (sidewalk melting salt or crushed water softener pellets)
- Crushed clinkers from a coal furnace
- Vermiculite or pearlite (garden shop)
- Small fossil fragments (broken shells)
- Add any other rocky planet, rock fragments or synthetic materials that meet classroom needs – Make sure materials are sterile and free of bacteria

B. Scoop equal quantities of crustal materials into heavy duty zipper bags.

Printing:

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

STEP 1: ENGAGE (~10 minutes)

Sample Return Story-Telling

Choose one of the following and read it to the students:

A. Fiction Story: "A new planet has been discovered in another solar system. Scientists are curious about the history of this new planet and whether there are living creatures or once-living creatures on the planet. A rover has sent a sample of the planet back to Earth. You have a sample of the planet you will explore. Did life ever exist on this new planet? How would you know if it did?"

B. Non-Fiction Explanation: Future Mars exploration includes rovers that will collect samples of the planet and return those samples back to Earth for investigation. You currently have a sample collected from Earth that could represent a sample return in

the future. How do scientists learn about a planet from researching a crustal sample? How can we tell if life ever existed on the planet?

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 (~20 minutes)
Exploring Crustal Materials

A. Hand out crustal materials, *(A) Sorting Graph Paper*, and *(B) Classifications sheet*

B. Students will now observe the crustal materials and begin sorting. To do this, pour the contents of the bag onto the *(A) Sorting Graph Paper*. For this stage of sorting, have students generate their own classification scheme. The *(A) Sorting Graph Paper* is also marked for size.

a. Tell student to organize the substances found in the bag in any way they see fit; for example, students might organize the materials by size or color.

C. Ask students to identify the key characteristics they used in their classification scheme. Place these key characteristics in the circles provided on the *(B) Classifications sheet*, then write the name of, or draw the crustal materials that belong in each of the classifications.

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)
Sharing Classification Schemes

A. Ask students to share their classification criteria. Discuss any criteria that are very common in class, and those that are unique. Point out that scientists complete the same process. Refer to **Teacher Tip** for more information.

Teacher Tip: Mystery Planet validates and reinforces the fact that scientists can look at the same data and see different things or come to different conclusions. This is the way science works and what drives science to more questions. These types of questions also drive exploration. Landing sites on Mars, for instance, can be chosen because there is a question as to what processes formed an area. Sending a spacecraft to help answer some of those questions is one way to determine which scientific hypothesis is correct.

STEP 4: ELABORATE (~25 minutes)
Story-telling

A. Ask students to take out a sheet of notebook paper (or teacher may hand out drawing paper).

B. Student will write a story or draw a picture explaining(?) the geologic history of the area their crustal material might have come from.

C. Ask students to consider what the environment may have been like, and what types of animals, plants, fungus, or bacteria might have existed. The drawing should be in comic strip form demonstrating changes over time while the story is a chronological march through the history of the area.

STEP 5: EVALUATE (~25 minutes)
Concept Mapping

A. Hand out *(C) Concept Mapping Sheet* - 1 per student

B. Based on classroom conversation and classification of crustal materials, have students explain what they now understand about the planet or region from where this sample came.

C. Ask students to create a concept map diagramming their classification scheme. An example has been provided on the *(C) Concept Mapping Sheet*.

6.0 Extensions

Have students revisit their classifications to see if they can sort them into elements, mixtures, or compounds.

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 *(D) "Mystery 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.

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

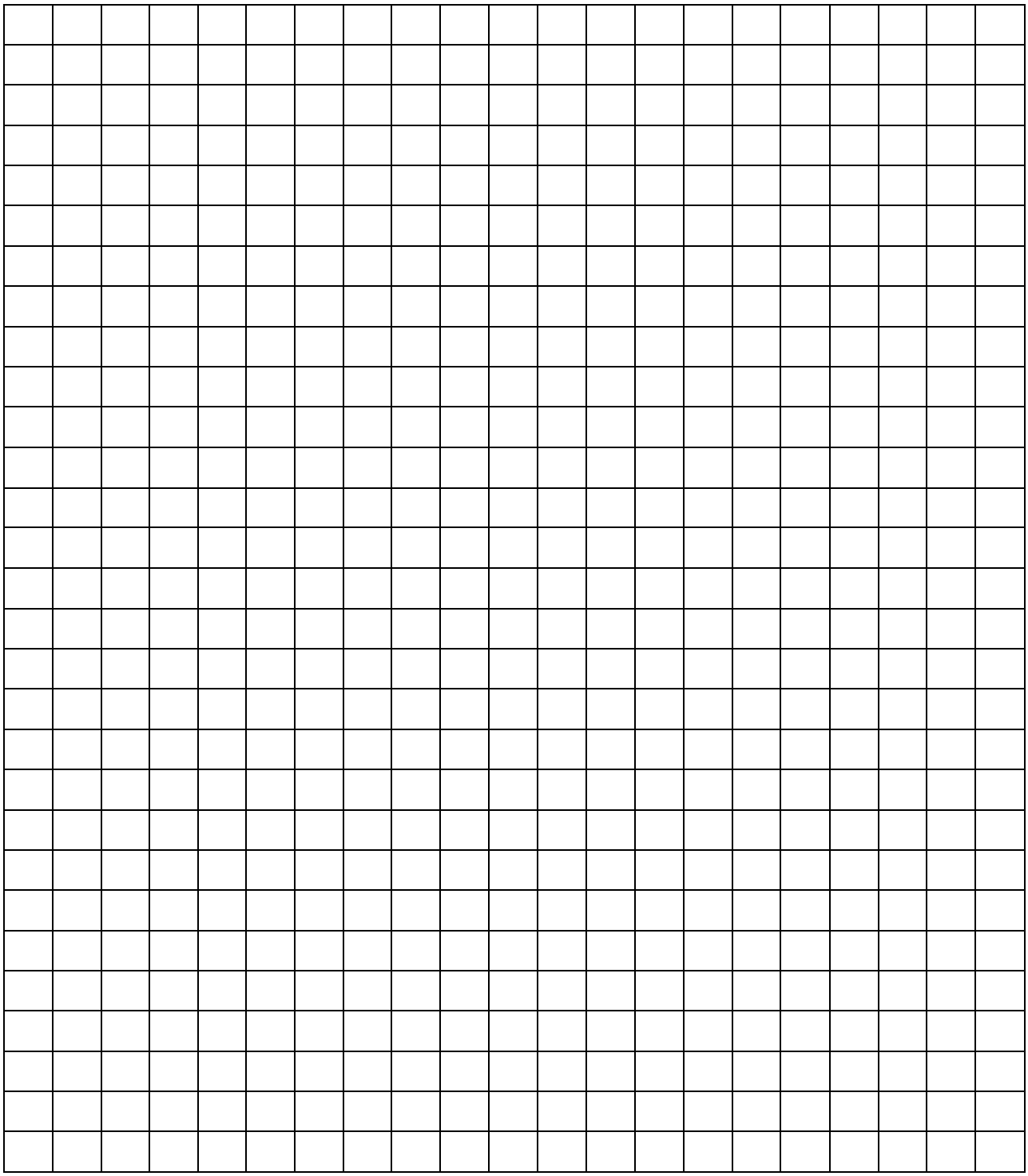
National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, 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/

Vasquez, J.A., Comer, M.W., & Troutman, F. (2010). *Developing visual literacy in science k-8*. Arlington, VA: NSTA Press.

Additional information about obtaining prepared "mystery" planet crustal material 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.

(A) Student Resource. Sorting Graph Paper



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½ inch

(B) Student Worksheet. Classification Sheet

NAME:_____

(C) Student Worksheet. Concept Mapping

NAME:_____

Create a concept map, showing the criteria you have chosen for sorting (classifying) your Mystery Planet crustal materials. An example has been provided to get you started on your map.

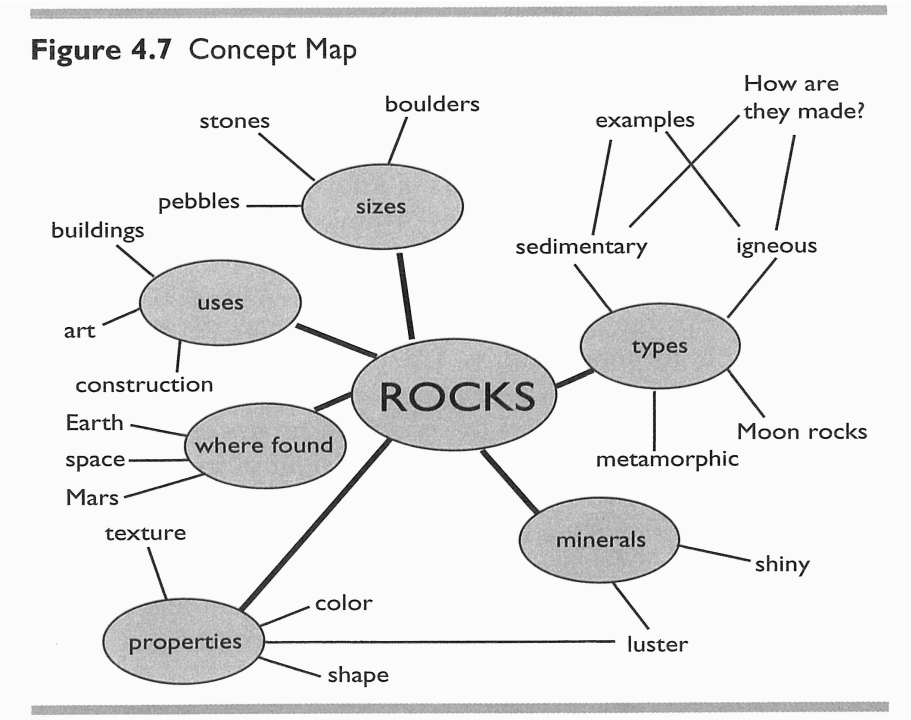


*Image Credit: *Developing Visual Literacy in Science K-8, National Science Teachers Association*

(D) 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 identify criteria necessary to sort and classify materials and relate them to the geologic history of a region

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

National Science Education Standards (NSES)
(B) Physical Science: Properties of Objects and Materials

Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers (Grades K-4: B1a).

Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made and those properties can be used to separate or sort a group of objects or materials (Grades K-4: B1b).

Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling. (Grades K-4: B1c).

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).

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

Learning Outcome	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.

(D) Teacher Resource. Mystery Planet Rubric (2 of 3)

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

National Science Education Standards (NSES)
(B) Physical Science: Properties of Objects and Materials

Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers (Grades K-4: B1a).

Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made and those properties can be used to separate or sort a group of objects or materials (Grades K-4: B1b).

Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling. (Grades K-4: B1c).

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).

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

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1b. to explain the classification scheme used	Explanation is complex and thoughtful.	Explanation is thoughtful.	Explanation is somewhat thoughtful.	Explanation is basic.

(D) Teacher Resource. Mystery Planet Rubric (3 of 3)

National Science Education Standards (NSES)
(D) Earth and Space Science: Properties of Earth Materials

Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use (Grades K-4: D1a).

Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply (Grades K-4: D1b).

Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time (Grades K-4: D1c).

National Science Education Standards (NSES)
(D) Earth and Space Science: Changes in the Earth and Sky

The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes (Grades K-4: D3a).

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).

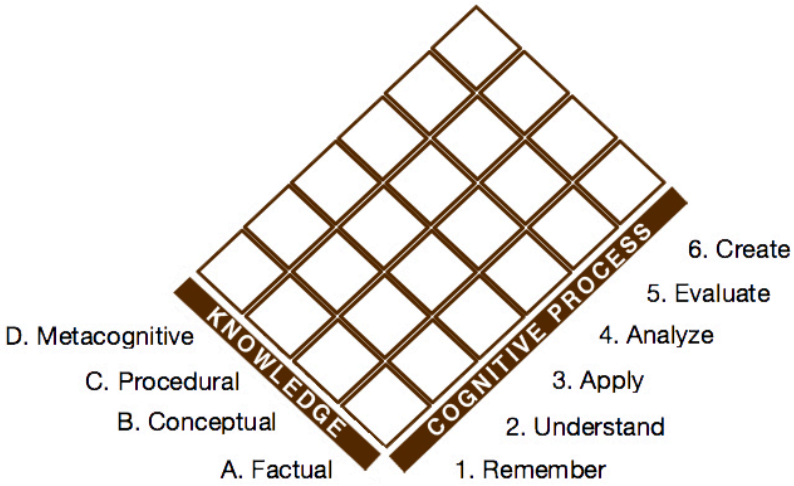
National Science Education Standards (NSES)
(D) Earth and Space Science: Earth’s History

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).

Learning Outcome	Expert	Proficient	Intermediate	Beginner
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..

(E) 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.

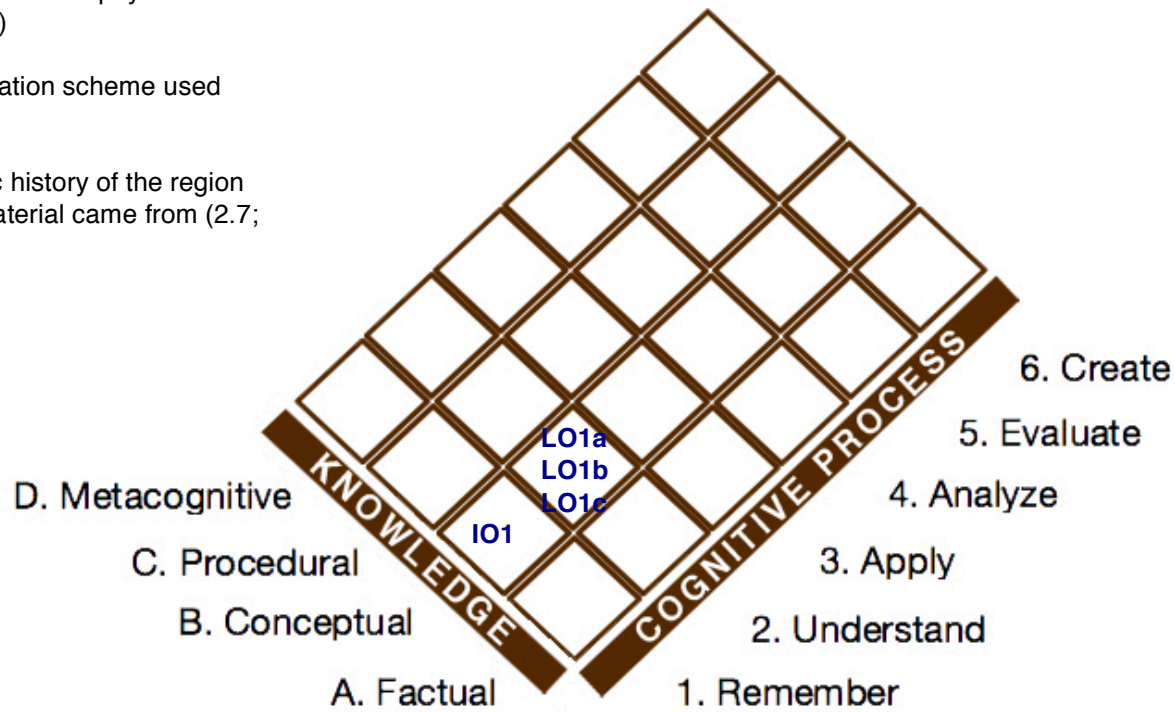
Knowledge	Cognitive Process
A. Factual **Aa:** Knowledge of Terminology **Ab:** Knowledge of Specific Details & Elements **B. Conceptual** **Ba:** Knowledge of classifications and categories **Bb:** Knowledge of principles and generalizations **Bc:** Knowledge of theories, models, and structures **C. 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)

(E) 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.

IO 1: **to identify** criteria necessary to sort and classify materials and relate them to the geologic history of a region (1.1; Ba)

- **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)



(E) 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 (E, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (E, 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 identify criteria necessary to sort and classify materials and relate them to the geologic history of a region

1.1: to identify

Ba: knowledge of classifications and categories

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