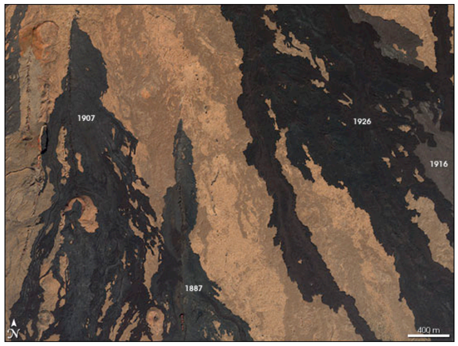
Lava Layering

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



WHAT STUDENTS DO: Sequence Lava Flow Events using Drill Cores and Cuts.

Students will sequence lava flows produced by multiple eruptions. Baking soda, vinegar, and play dough, are used to model fluid lava flows. Students will be asked to observe where the flows travel, make a model, and interpret the stratigraphy.

NRC CORE & COMPONENT QUESTIONS

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

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

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

NRC Component Question: ESS1C: The History of Planet Earth

INSTRUCTIONAL OBJECTIVES

Students will be able

IO1: to model a series of lava flows and reconstruct geologic events using relative dating techniques

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

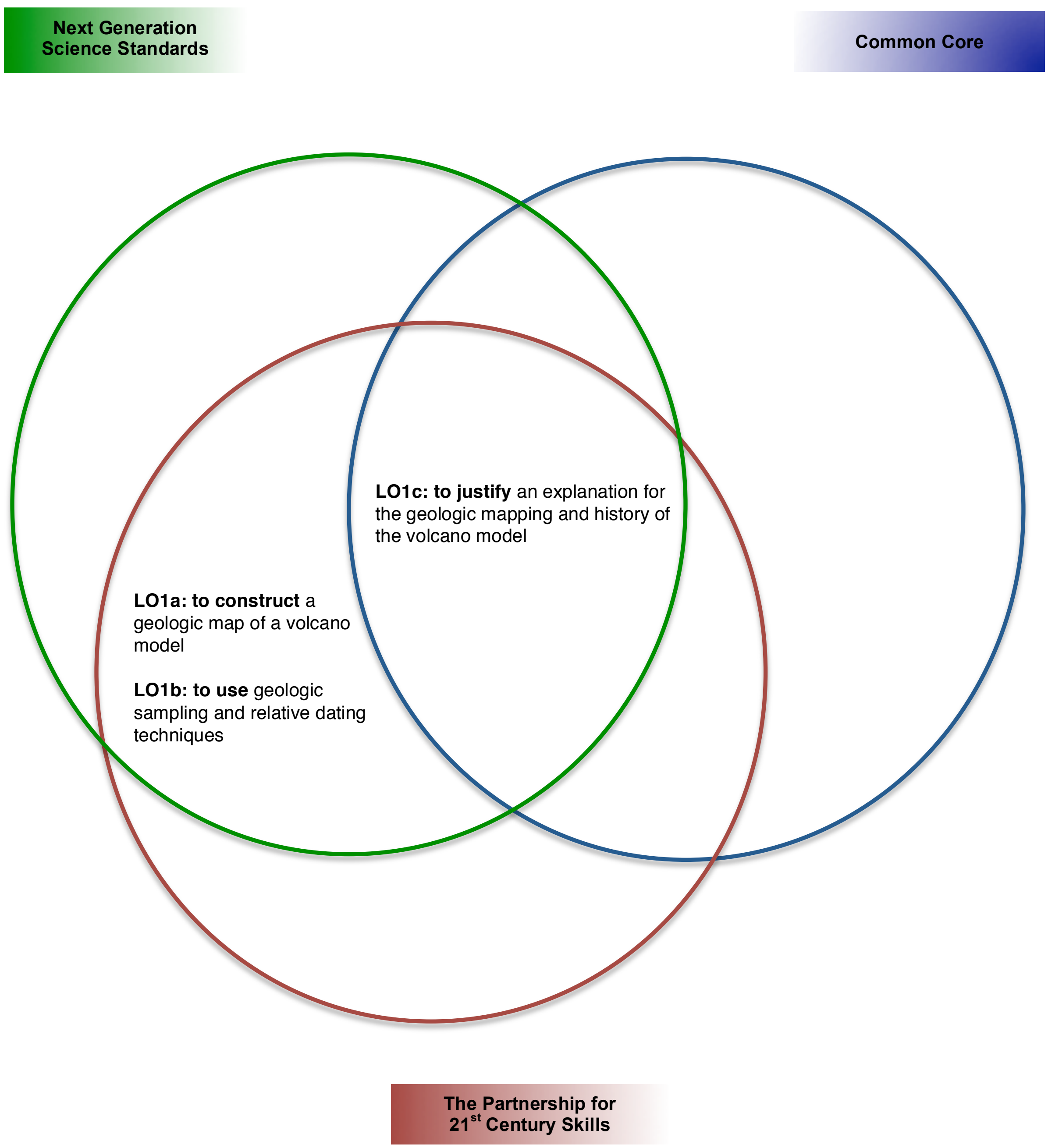
How do people reconstruct and date events in Earth's planetary history?

NRC Component Question: ESS1C: The History of Planet Earth

Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: **to model** a series of lava flows and reconstruct geologic events using relative dating techniques	**LO1a: to construct** a geologic map of a volcano model **LO1b. to use** geologic sampling and relative dating techniques **LO1c. to justify** an explanation for the geologic mapping and history of the volcano model	**NSES: UNIFYING CONCEPTS & PROCESSES:** **K-12: (A2) Evidence, models, and explanations** **NGSS Disciplinary Core Idea:** **ESS1.C: The History of Planet Earth** **NGSS Practices:** **Asking Questions and Defining Problems** **Developing and Using Models** **Planning and Carrying out Investigations** **Analyzing and Interpreting Data** **Constructing Explanations and Designing Solutions** **Engaging in Argument from Evidence** **Understandings about the Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** **Scientific Knowledge is Open to Revision in Light of New Evidence** **NGSS Cross-Cutting Concept:** **Scale, Proportion, and Quantity** **Understandings about the Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** **Science Addresses Question about the Natural and Material World**

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. Lava Layering 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 a series of lava flows and reconstruct geologic events using relative dating techniques

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)
Disciplinary Core Idea: ESS1.C The History of Planet Earth
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

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

- Ask questions
  - that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.

- to identify and/or clarify evidence and/or the premise(s) of an argument.
- that require sufficient and appropriate empirical evidence to answer.

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

- Develop and/or use a model to predict and/or describe phenomena.
- 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)

- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

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: LO1b, LO1c)

- Construct an explanation using models or representations.

Next Generation Science Standards (NGSS)
Practices: Engaging in Argument from Evidence
(Learning Outcomes Addressed: LO1c)

- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Next Generation Science Standards (NGSS)
Understandings about the Nature of Science Practices: Scientific Knowledge is Based on Empirical Evidence
(Learning Outcomes Addressed: LO1b)

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

Next Generation Science Standards (NGSS)
Understandings about the Nature of Science Practices: Scientific Knowledge is Open to Revision in Light of New Evidence
(Learning Outcomes Addressed: LO1c)

- Scientific explanations are subject to revision and improvement in light of new evidence.
- Science findings are frequently revised and/or reinterpreted based on new evidence.

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

- Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.

Next Generation Science Standards (NGSS)
Understandings about the Nature of Science Cross-Cutting Concepts: Scientific Knowledge assumes an Order and Consistency in Natural Systems
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Next Generation Science Standards (NGSS)
Understandings about the Nature of Science Cross-Cutting Concepts: Science Addresses Questions about the Natural and Material World
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Scientific knowledge is constrained by human capacity, technology, and materials.

Common Core State Standards
Writing Standards for Literacy in History/Social Studies, Science, and Tehcnical Subjects: Text Types and Purposes
(Learning Outcomes Addressed: LO1c)

- Write arguments focused on discipline-specific content.
    - Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.
    - Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
    - Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.

- Establish and maintain a formal style.
- Provide a concluding statement or section that follows from and supports the argument presented.

Common Core State Standards
Writing Standards for Literacy in History/Social Studies, Science, and Tehcnical Subjects: Production and Distribution
(Learning Outcomes Addressed: LO1c)

- Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

21st Century Skills
Critical Thinking
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Students plan and conduct scientific investigations and write detailed explanations based on their evidence. Students compare their explanations to those made by scientists and relate them to their own understandings of the natural and designed worlds.

21st Century Skills
Communication
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- Students can identify conventions for writing and speaking scientifically that distinguish scientific communication from other types of expression, and describe reasons behind those differences such as the need in science for precision, detail, and evidence over opinion.

21st Century Skills
Collaboration
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

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

(D) Teacher Resource. Lava Layering 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 construct a geologic map of a volcano model	Maps accurately and effectively communicate layering structure of the volcano model.	Maps accurately communicate the layering structure of the volcano model.	Maps communicate layering of the volcano model.	Maps demonstrate a volcano model.
LO1b: to use geologic sampling and relative dating techniques	Model utilizes all materials effectively and as directed by the facilitator. Sampling techniques are used thoughtfully with the intention of collecting the most information.	Model uses all materials and follows facilitator instructions. Sampling techniques are used with some thought to appropriate placement for quality information.	Model uses all materials and/or sampling techniques are used with some thought to appropriate placement.	Materials usage and/or sampling technique is based on student preference and desires.
LO1c: to justify an explanation for the geologic mapping and history of the volcano model	Student is able to identify and explain the strong connection between sampling techniques and development of a geologic map.	Student is able to identify and explain the connection between sampling techniques and geologic mapping.	Student is able to identify the connection between sampling techniques and geologic mapping.	Student explains sampling techniques separately from geologic mapping.

(L) Teacher Resource. Lava Layering Rubric (2 of 3)

Partnership for 21st Century Skills

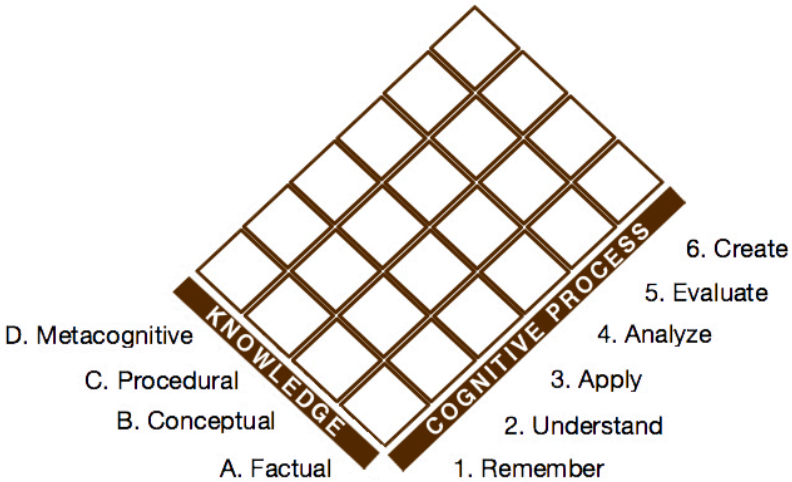
	Expert	Proficient	Intermediate	Beginner
Effectiveness of collaboration with team members and class.	Extremely Interested in collaborating in the simulation. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure 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.
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.
Effectiveness of critical thinking	Develops detailed explanations based on credible evidence. Compares explanations to those made by scientists and relates them to their own understandings of the geology.	Develops detailed explanations based on credible evidence. Relates them to their own understandings of the geology.	Develops explanations. Relates explanation to their own understandings of the geology.	Attempts to explain the geology based on own understanding of geology.

(L) Teacher Resource. Lava Layering Rubric (3 of 3)

Common Core – ELA

	Expert	Proficient	Intermediate	Beginner
Text Types and Purpose	Introduces topic clearly, provides a general observation and focus, and groups related information logically; Develops the topic with facts, definitions, concrete details, or other examples related to the topic; Links ideas using words, phrases, and clauses; Use domain-specific vocabulary to explain the topic; Provides a concluding statement related to the explanation.	Introduces topic clearly, provides a general observation, or groups related information logically; Develops the topic with concrete details, or other examples related to the topic; Links ideas using words or phrases; Uses domain-specific vocabulary to explain the topic; Provides a concluding statement related to the explanation.	Introduces topic, provides a general observation; Develops the topic with details, or other examples related to the topic; Links ideas using words or phrases; Uses domain-specific vocabulary to explain the topic; May or may not provide a concluding statement.	Introduces topic; Develops the topic with details, or other examples, potentially unrelated; Uses specific vocabulary to explain the topic; May or may not provide a concluding statement.
Production and Distribution of Writing	Produces clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.	Produces clear and coherent writing in which the development and organization are appropriate to task, purpose, or audience.	Produces clear writing in which the development and organization are appropriate to task, purpose, or audience.	Produces writing in which the development is appropriate to task, purpose, or audience.

(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)

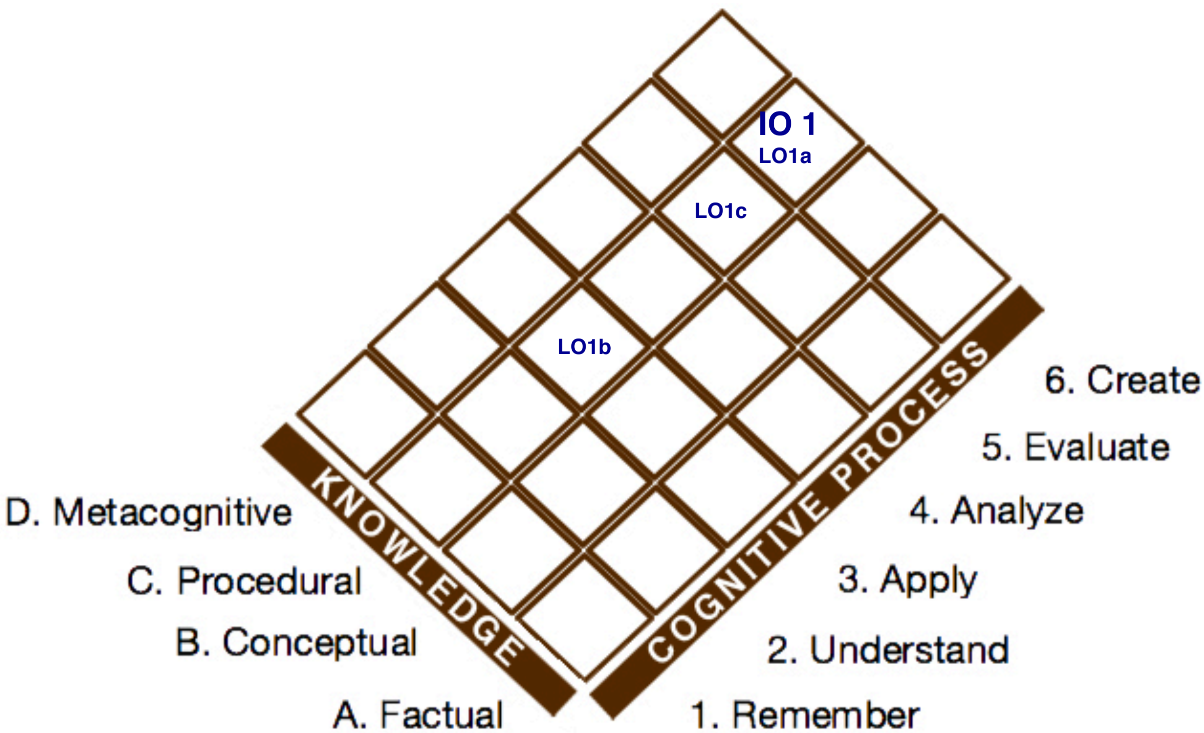
(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

IO1: to model a series of lava flows and reconstruct geologic events using relative dating techniques (6.3; Cb)

LO1a: to construct a geologic map of a volcano model (6.3; Cb)

LO1b. to use geologic sampling and relative dating techniques (3.2; Cb)

LO1c. to justify an explanation for the geologic mapping and history of the volcano model (5.2; Cb)



(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** a series of lava flows and reconstruct geologic events using relative dating techniques (6.3; Cb)

6.3: to construct
Cb: knowledge of subject-specific techniques and methods

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

LO1a: to construct a geologic map of a volcano model
6.3: to construct
Cb: knowledge of subject-specific techniques and methods

LO1b: to use geologic sampling and relative dating techniques
3.2: to use
Cb: knowledge of subject-specific techniques and methods

LO1c: to justify an explanation for the geologic mapping and history of the volcano model
5.2: to justify
Cb: knowledge of subject-specific techniques and methods