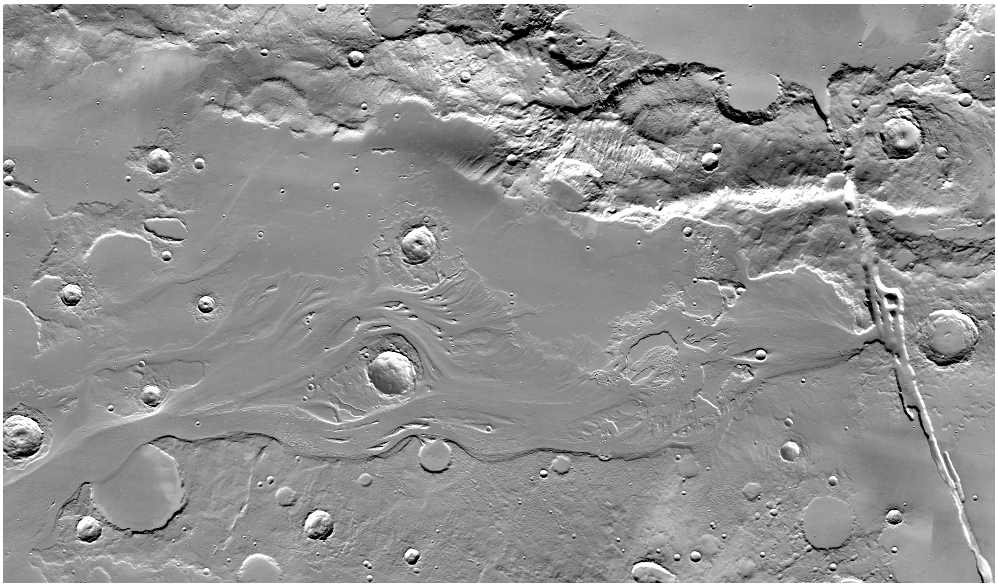
Question Mars

Middle School Alignment Document
National Resource Council Framework, Next Generation Science Standards, Common Core State Standards, and 21st Century Skills



WHAT STUDENTS DO: Generate a Research Question and/or Hypotheses for Mars

In this activity, students walk in the shoes of real planetary scientists and experience a step in the process of science; developing an hypotheses and testable question. Students are tasked with using the topic identified in the Mars Image Analysis activity to establish working hypotheses and a research question about the surface of Mars. The purpose of this lesson is for students to use a critical thinking and collaborative approach to scientific research in planetary geology. Using scientific observations and inferences, students will:

- Generate a "big picture" question related to Mars;
- Generate working hypotheses related to Mars geology; and
- Generate a research question related to Mars geology based on scientific observations.

NRC FRAMEWORK / NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES (IO)
WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT? *NGSS Core Question: ESS1: Earth's Place in the Universe*	*Students will be able to:* **IO1: Generate a research question and testable**

Last edited: February 25, 2016

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

NGSS ESS1.C: The History of the Planet Earth

hypothesis based on observations of phenomena and credible information that can be investigated to describe the natural world patterns in and/or evidence about Martian geology, past or present.

1.0 About This Activity

The 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 Mars instructional series. The 5E stages can be cyclical and iterative.

The format for developing a question was guided by statements made by Bybee in "Scientific and engineering practices in K-12 classrooms: Understanding a framework for K-12 science education" publish by NSTA. Here Bybee explained that the term "practices" was a much more accurate explanation of scientific inquiry. These practices "involve doing and learning in such a way that cannot be really separated." The process for reaching a scientific research question in this lesson has been discussed and vetted through planetary scientists actively involved in research.

2.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

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).

Important Note: This lesson is color-coded to help teachers identify each of the three dimensions of NGSS. The following identifying colors are used: Practices are blue, Cross-Cutting Concepts are green, and Disciplinary Core Ideas are orange.

This color-coding is consistent with the NGSS Performance Expectations and Foundation Boxes.

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?

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

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

NGSS ESS1.C: The History of the Planet Earth

Instructional Objective (IO) *Students will be able to:*	**Learning Outcomes (LO)** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: **Generate** a research question and testable hypothesis based on observations of phenomena and credible information that can be investigated to describe the natural world patterns in and/or evidence about Martian geology, past or present.	**LO1a.** to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features **LO1b.** to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features **LO1c.** to choose a testable working hypothesis that will guide the scientific question based on availability of data in the JMARS	**DISCIPLINARY CORE IDEA:** **ESS1.C: The History of Planet Earth Practices** **PRACTICES:** 1. Asking Questions and Defining Problems 2. Developing and Using Models 3. Constructing Explanations and Designing Solutions 4. Engaging in Argument from Evidence 5. Obtaining, Evaluating, and Communicating Information **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** **CROSSCUTTING CONCEPTS:** 1. Patterns 2. Cause and Effect 3. Systems and System Models **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** **INTERDEPENDENCE OF SCIENCE, ENGINEERING, AND TECHNOLOGY**

	modeling tool and utilizing geologic evidence from credible resources and class discourse		

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

Use the *(J) Question Mars 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 the Next Generation Science Standards, Common Core State Standards, and 21st Century Skills.

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

(I) Teacher Resource. Question Mars NGSS Alignment (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.

Related Standard(s)

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

(MS-ESS1-4)

Next Generation Science Standards Alignment (NGSS)

Instructional Objective *Students will be able to*	**Science and Engineering Practices**	**Disciplinary Core Idea**	**Crosscutting Concepts**
IO1: **Generate a research question and testable hypothesis based on observations of phenomena and credible information that can be investigated to describe the natural world patterns in and/or evidence about Martian geology, past or present.**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Ask questions to determine relationships between independent and dependent variables and relationships in models. Ask questions that require sufficient and appropriate empirical evidence to answer. Ask questions that can be investigated within the scope of the classroom, museums, and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Constructing Explanations and Designing Solutions:**	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns** Patterns can be used to identify cause and effect relationships. **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Systems and System Models** Models are limited in that they only represent certain aspects of the system under study. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in

	Construct an explanation using models or representations. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** An hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory.		natural systems occur in consistent patterns that are understandable through measurement and observation. **Interdependence of Science, Engineering, and Technology:** Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

(I) Teacher Resource. Question Mars NGSS Alignment (2 of 3)

Next Generation Science Standards Alignment (NGSS)

Learning Outcomes *Students will demonstrate the measurable abilities*	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: **to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Ask questions to determine relationships between independent and dependent variables and relationships in models. Ask questions that require sufficient and appropriate empirical evidence to answer. Ask questions that can be investigated within the scope of the classroom, museums, and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns** Patterns can be used to identify cause and effect relationships. **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

LO1b: **to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features**	**Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** An hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory.	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns** Patterns can be used to identify cause and effect relationships. **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
LO1c: **to choose a testable working hypothesis that will guide the scientific question based on availability of data in the JMARS modeling tool and utilizing geologic evidence from credible resources and class discourse**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Ask questions to determine relationships between independent and dependent variables and relationships in models. Ask questions that require sufficient and appropriate empirical evidence to answer. Ask questions that can be investigated within the scope of the classroom, museums, and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Constructing Explanations and Designing Solutions:** Construct an explanation using models or representations. **Obtaining, Evaluating, and Communicating**	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Systems and System Models** Models are limited in that they only represent certain aspects of the system under study. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. **Interdependence of Science, Engineering, and Technology:** Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

	Information: Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** An hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory.		

(I) Teacher Resource. Question Mars NGSS Individual Activity Alignment (3 of 3)

Next Generation Science Standards Activity Alignments (NGSS)

Activity	Phases of 5E Instructional Model	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
(A) Introduction	**Engage**	**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** A hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory		**Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
(B) Questions and Hypotheses	**Engage** **Explore**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **Constructing Explanations and Designing Solutions:** Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns:** Patterns can be used to identify cause and effect relationships. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

(C) Identifying the Big Picture Question	**Explain**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns:** Patterns can be used to identify cause and effect relationships. **Cause and Effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
(D) Identifying the Explanations	**Elaborate**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **Constructing Explanations and Designing Solutions:** Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. **Engaging in Argument from Evidence:** 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.	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns:** Patterns can be used to identify cause and effect relationships. **Systems and System Models** Models are limited in that they only represent certain aspects of the system under study. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.
(E) Writing a Research Question	**Elaborate**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	**ESS1.C: The History of Planet Earth:** 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	**Patterns:** Patterns can be used to identify cause and effect relationships. **Cause and Effect: Mechanism and**

		Ask questions to determine relationships between independent and dependent variables and relationships in models. Ask questions that require sufficient and appropriate empirical evidence to answer Ask questions that can be investigated within the scope of the classroom ... with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Engaging in Argument from Evidence:** 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.	dates, not an absolute scale. (MS-ESS1-4)	**Prediction** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.
(F) Writing a Testable Hypothesis	**Evaluate**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Ask questions to determine relationships between independent and dependent variables and relationships in models. Ask questions that require sufficient and appropriate empirical evidence to answer Ask questions that can be investigated within the scope of the classroom ... with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Engaging in Argument from Evidence:** 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.	**ESS1.C: The History of Planet Earth:** 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. (MS-ESS1-4)	**Patterns:** Patterns can be used to identify cause and effect relationships. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.

(J) Teacher Resource. Question Mars CCSS Alignment (1 of 2)

Common Core State Standards

Instructional Objective *Students will be able to*	Reading Standards for Literacy in Science and Technical Subjects (6-8)	Writing Standards for Literacy in Science and Technical Subjects (6-8)	Speaking and Listening Standards (6-8)
IO1: **Generate a research question and testable hypothesis based on observations of phenomena and credible information that can be investigated to describe the natural world patterns in and/or evidence about Martian geology, past or present.**	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. **Craft and Structure:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. **Integration of Knowledge and Ideas:** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	**Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. **Research to Build and Present Knowledge:** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. Draw evidence from informational texts to support analysis reflection, and research	**Comprehension and Collaboration:** **Grade 6:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. • Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. • Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not. **Grade 7:**

			Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. • Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. • Acknowledge new information expressed by others and, when warranted, modify their own views. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence. **Grade 8:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. • Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. • Acknowledge new information expressed by

			others, and, when warranted, qualify or justify their own views in light of the evidence presented Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.

(J) Teacher Resource. Question Mars CCSS Alignment (2 of 2)

Common Core State Standards

Learning Outcomes *Students will demonstrate the measurable abilities*	**Reading Standards for Literacy in Science and Technical Subjects (6-8)**	**Writing Standards for Literacy in Science and Technical Subjects (6-8)**	**Speaking and Listening Standards (6-8)**
LO1a: **to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features** **LO1b:** **to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features**	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. **Craft and Structure:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. **Integration of Knowledge and Ideas:** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	**Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. **Research to Build and Present Knowledge:** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. Draw evidence from informational texts to support analysis reflection, and research	**Comprehension and Collaboration:** **Grade 6:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. • Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. • Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not. **Grade 7:** Engage effectively in a range of collaborative

LO1c: to choose a testable working hypothesis that will guide the scientific question based on availability of data in the JMARS modeling tool and utilizing geologic evidence from credible resources and class discourse			discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. • Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. • Acknowledge new information expressed by others and, when warranted, modify their own views. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence. **Grade 8:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. • Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. • Acknowledge new information expressed by others, and, when warranted, qualify or justify

			their own views in light of the evidence presented Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.

(K) Teacher Resource. Question Mars 21st Century Skills Alignment

21st Century Skills

Learning Outcomes *Students will demonstrate the measurable abilities*	21st Century Skill	Grade 8 Benchmark
LO1a: **to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features**	**Creativity and Innovation**	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.
	Social and Cross-Cultural Skills	Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
	Collaboration	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
LO1b: **to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features**	**Creativity and Innovation**	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.
	Collaboration	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Information Literacy	Students are able to locate reliable scientific information in reputable reference books, back issues of journals and magazines, on websites, and in computer databases.
	Leadership and Responsibility	Students understand the importance of proper citations and respect for intellectual property rights.
LO1c: **to choose a testable working hypothesis that will guide the scientific question based on**	**Creativity and Innovation**	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.
	Communication	Students are familiar with the use of computational models as tools to describe and predict real-world phenomena.

availability of data in the JMARS modeling tool and utilizing geologic evidence from credible resources and class discourse	**Collaboration**	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Information Literacy	Students are able to locate reliable scientific information in reputable reference books, back issues of journals and magazines, on websites, and in computer databases.
	Leadership and Responsibility	Students understand the importance of proper citations and respect for intellectual property rights.

(J) Teacher Resource. Question Mars NGSS Rubric (1 of 3)

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

Next Generation Science Standards Alignment (NGSS)

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a. to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features	Research question is based on specific scientific observations and is scientifically sound to explain a potential relationship or pattern observed.	Research question is based on specific scientific observations and loosely explains the potential relationship or pattern observed.	Research question is based on a scientific observation.	Research question remains in the form of a Big Picture Question or based on a scientific misconception.
LO1b: to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features	Working hypotheses use an understanding of Earth or Mars geology (even out of the box hypotheses) and explain scientific observations and the potential relationship or patterns observed.	Most working hypotheses use an understanding of Earth or Mars geology (even out of the box hypotheses) and explain scientific observations and the potential relationship or patterns observed.	Working hypotheses list may be very short and/or are loosely based on an understanding of Earth and Mars geology and the potential relationship or pattern observed.	Hypotheses are based on scientific misconceptions or are unrelated to the scientific observations and Big Picture Question.
LO1c: to choose a testable working hypothesis that will guide the scientific question based on availability of data in the JMARS modeling tool and utilizing geologic evidence from credible resources and class discourse	Chosen working hypothesis is testable using data (such as from the JMARS modeling tool) and tools (layers) suggested are appropriate to the type of research to be conducted.	Chosen working hypothesis is testable using data (such as from the JMARS modeling tool) and most tools (layers) suggested are appropriate to the type of research to be conducted.	Chosen working hypothesis is testable using data (such as from the JMARS modeling tool), however tools (layers) suggested may not yield the evidence needed to adequately answer the question.	Working hypothesis chosen cannot be answered using data.

(J) Teacher Resource. Question Mars CCSS Rubric (2 of 3)

Common Core – ELA

	Expert	Proficient	Intermediate	Beginner
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.
Research to Build and Present Knowledge	Recalls relevant information from experience; summarizes information in finished work; draws evidence from informational texts to support analysis, reflection, and research.	Recalls relevant information from experience; draws evidence from informational texts to support analysis, reflection, and research.	Recalls information from experience; draws evidence from informational texts to support analysis, reflection, and research.	Recalls information from experience.
Key Ideas and Details	Uses specific evidence from text to support ideas. Develops an accurate and in depth summary, extending prior understanding and opinions.	Uses specific evidence from text to support ideas. Develops an in depth summary, extending prior understanding and opinions.	Uses information from text to support ideas. Develops a summary, extending prior understanding and opinions.	Supports ideas with details, relying on prior understanding and opinions.
Craft and Structure	Develops strong, accurate geologic vocabulary through feature identification, JMARS introduction, and background research on those features.	Develops strong, geologic vocabulary through feature identification, JMARS introduction, and background research on those features.	Develops vocabulary through feature identification and JMARS introduction.	Vocabulary is rudimentary toward geology and possibly based on prior understanding.
Integration of Knowledge	Successfully combines information from lesson with text found on web-based resources to develop a deeper understanding of a geologic topic.	Successfully combines information from lesson with text found on web-based resources to develop an understanding of a geologic topic.	Combines information from lesson with text found on web-based resources to develop a summary of a geologic topic.	References text or pastes information from web-based resources to develop a summary of a geologic topic.

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.

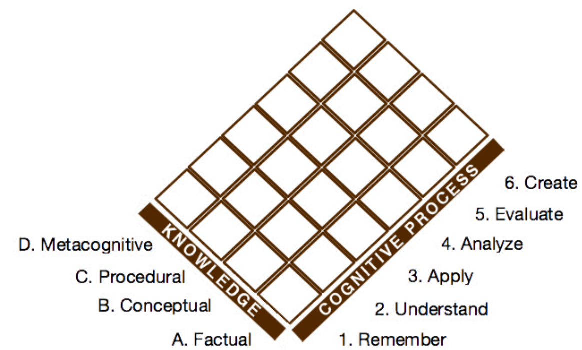
(J) Teacher Resource. Question Mars 21st Century Skills Rubric (3 of 3)

Partnership for 21st Century Skills

	Expert	Proficient	Intermediate	Beginner
Effectiveness of social and cross-cultural collaboration with team members and class.	Extremely interested in collaborating in the group. 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 group. Actively provides suggestions and occasionally listens to suggestions from others. Refines suggestions from others.	Interested in collaborating in the group. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the group.
Effectiveness of information and media literacy in background research	Locates reliable scientific information in reputable reference books, back issues of journals and magazines, on websites, and in computer databases. Actively listens to suggestions and ideas from others while asking clarifying questions to ensure claims are consistent with the evidence provided.	Locates reliable scientific information in reputable reference books, back issues of journals *or* magazines, on websites. Listens to suggestions and ideas from others while asking clarifying questions to ensure claims are consistent with the evidence provided.	Locates scientific information from a mixed variety of sources, some reputable, others less likely. Listens to suggestions and ideas from others and asking clarifying questions while following their direction.	Locates information from websites indiscriminately. Listens to the suggestions provided by others and follows their direction.
Effectiveness in communication	Communicates ideas in a clearly organized and logical manner using a model that is consistently maintained.	Communicates ideas in an organized manner using a model that is consistently maintained.	Communications of ideas are organized, but not consistently maintained.	Communicates ideas as they come to mind.
Effectiveness of leadership and responsibility for citation and property rights	Demonstrates the importance of proper citations and respect for intellectual property rights through thorough written and verbal citation of sources used in research.	Demonstrates respect for intellectual property rights through thorough written and verbal citation of sources used in research. Citation of work is nearly formatted correctly.	Demonstrates respect for intellectual property rights through thorough written citation of sources used in research. Citation of work may be nearly formatted correctly.	If citation is provided, it is in URL form and lacks formatting. Citation may be missing.
Effectiveness of Creativity, Innovation and Flexibility	Demonstrates a wide variety of generating and testing of ideas to achieve a successful research question.	Demonstrates a variety of generating and testing of ideas to achieve a successful research question.	Demonstrates a wide variety of ideas to achieve a successful research question.	Demonstrates ideas to achieve a design for personal gain or entertainment.

(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.



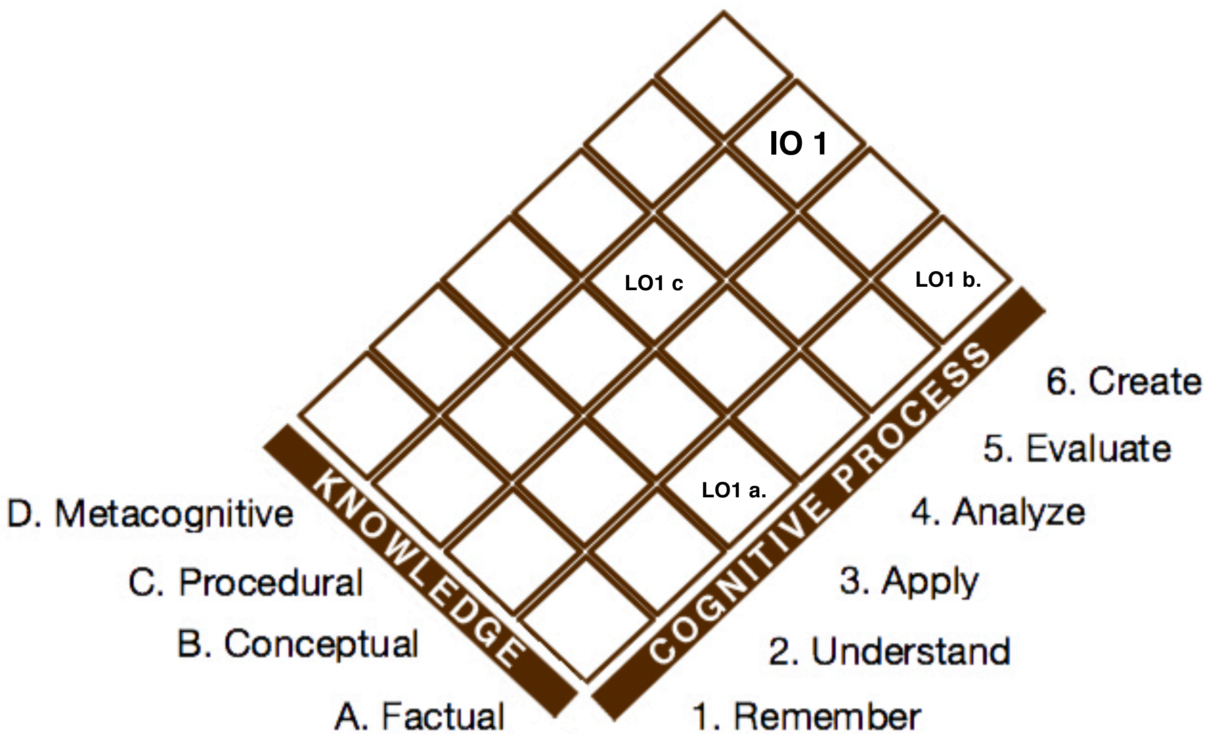
Knowledge	Cognitive Process
A. Factual **Aa:** Knowledge of Terminology **Ab:** Knowledge of Specific Details & Elements **B. Conceptual** **Ba:** Knowledge of classifications and categories **Bb:** Knowledge of principles and generalizations **Bc:** Knowledge of theories, models, and structures **C.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

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.

IO1: Generate a research question and testable hypothesis based on observations of phenomena and credible information that can be investigated to describe the natural world patterns in and/or evidence about Martian geology, past or present. (6.1; Cb)

LO1a. to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features (3.2; Ab)
LO1b. to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features (6.1; Ab)
LO1c. to choose a testable working hypothesis that will guide the scientific question based on availability of data in the JMARS modeling tool and utilizing geologic evidence from credible resources and class discourse (4.1; 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: Generate a research question and testable hypothesis based on observations of phenomena and credible information that can be investigated to describe the natural world patterns in and/or evidence about Martian geology, past or present.

6.1: to generate
Cb: knowledge of subject-specific techniques and methods

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

LO1a: to use scientific observations and content knowledge of natural geologic phenomena to guide the scientific question with emphasis on the patterns and potential relationships found between features

3.2: to use
Ab: knowledge of specific details and elements

LO1b: to construct a list of possible explanations (working hypotheses) of the natural geologic phenomena citing evidence from resources and class discourse with emphasis on the patterns and potential relationships found between features

6.1: to generate
Ab: knowledge of specific details and elements

LO1c: to choose a testable working hypothesis that will guide the scientific question based on availability of data in the JMARS modeling tool and utilizing geologic evidence from credible resources and class discourse

4.1: to select
Cb: knowledge of subject-specific techniques and methods