Mars Image Analysis

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

WHAT STUDENTS DO: Establish geologic sequences in a Mars image.

Students step into the shoes of real planetary scientists. Using large-format images of Mars, provided by Mars Education at Arizona State University, students reach conclusions about the geology of Mars. Students are tasked with identifying features on the surface of Mars, determining the surface history of the area, calculating the size of features, and developing research questions.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

WHAT IS THE UNIVERSE, AND 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 ESS1.C: The History of the Planet Earth

INSTRUCTIONAL OBJECTIVES (IO)

Students will be able to:

IO1: **Reconstruct geologic events using empirical evidence while assuming the laws of nature on Mars are relatively similar to those laws on Earth.**

IO2: **Respectfully debate a potential Mars geologic history research topic to elicit relevant information leading to revisions of thinking based on new evidence presented.**

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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**.

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's Place in the Universe

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

NRC ESS1.C: The History of the Planet Earth

Instructional Objective *Students will be able to*	Learning Outcomes *Students will demonstrate the measurable abilities*	Standards *Students will address*
IO1: **Reconstruct geologic events using empirical evidence while assuming the laws of nature on Mars are relatively similar to those laws on Earth.**	**LO1a. to identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning the laws of nature** **LO1b. to use natural laws of relative dating principles to construct the geologic history of a small portion of Mars** **LO1c. to construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and relationships found between features**	**DISCIPLINARY CORE IDEA:** **ESS1.C: The History of Planet Earth** (MS-ESS1-4) **PRACTICES:** 1. **Asking Questions and Defining Problems** 2. **Analyzing and interpreting Data** 3. **Using Mathematics and Computational Thinking** 4. **Constructing Explanations and Designing Solutions** 5. **Engaging in Argument from Evidence** 6. **Obtaining, Evaluating, and Communicating Information** **Scientific Knowledge is Open to Revision in Light of New Evidence** **CROSSCUTTING CONCEPTS:** 1. **Patterns** 2. **Cause and Effect: Mechanism and Prediction** 3. **Scale, Proportion and Quantity** 4. **Systems and System Models** **Science is a Way of Knowing** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**
IO2: **Respectfully debate potential Mars geologic history research topics and questions to elicit relevant information, using quantitative and qualitative evidence and**	**LO2a. to make a claim, supported by obtained evidence and use sound reasoning of systemic patterns in geologic observations of Mars** **LO2b. to generate background research utilizing credible sources as a**	

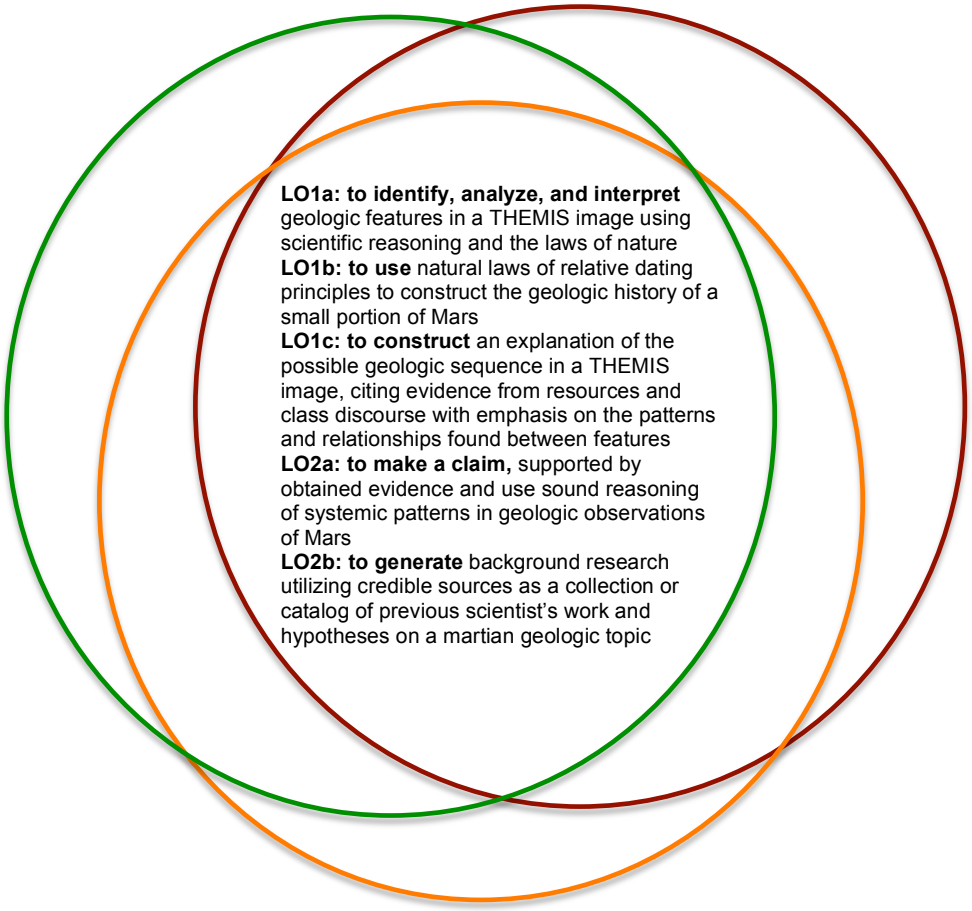
scientific reasoning based on personal observations and previous scientists work regarding patterns of change or possible relationships.	**collection or catalog of previous scientist's work and hypotheses on a martian geologic topic**		

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 and Math Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents.

Next Generation Science Standards

Common Core State Standards



The Partnership for 21st Century Skills

4.0 Evaluation/Assessment

Rubric*:* A rubric has been provided to assess student understanding of the activity and to assess metacognition. A copy has been provided in the Alignment Document for students to reference prior to the activity. 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. Mars Image Analysis 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: **Reconstruct geologic events using empirical evidence while assuming the laws of nature on Mars are relatively similar to those laws on Earth.**	**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.	**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)	**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.

(L) Teacher Resource. Mars Image Analysis NGSS Alignment (1 of 3)

Next Generation Science Standards Alignment (NGSS)

Instructional Objective *Students will be able to*	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO2: **Respectfully debate potential Mars geologic history research topics and questions to elicit relevant information, using quantitative and qualitative evidence and scientific reasoning based on personal observations and previous scientists work regarding patterns of change or possible relationships**	**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. **Using Mathematics and Computational Thinking:** Use mathematical representations to describe and/or support scientific conclusions and design solutions. Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. **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. Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **Engaging in Argument from Evidence:** Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.	**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 in rates of change and other numerical relationships can provide information about natural and human designed systems. 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 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. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. Science is a way of knowing used by many people, not just scientists.

	Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. 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.		

(L) Teacher Resource. Mars Image Analysis 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 identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning and the laws of nature**	**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. **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. **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)	**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 use natural laws of relative dating principles to construct the geologic history of a small portion of Mars**	**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. **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)	**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 construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and relationships found between features**	**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. **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). Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	**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 in rates of change and other numerical relationships can provide information about natural and human designed systems. 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. **Scale, Proportion, and Quantity:** Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. **Systems and System Models:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

(L) Teacher Resource. Mars Image Analysis 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
LO2a: **to make a claim, supported by obtained evidence and use sound reasoning of systemic patterns in geologic observations of Mars**	**Using Mathematics and Computational Thinking:** Use mathematical representations to describe and/or support scientific conclusions and design solutions. Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. **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. Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **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 in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. **Systems and System Models:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex 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 carefully considers and evaluates anomalies in data and evidence.

LO2b: **to generate background research utilizing credible sources as a collection or catalog of previous scientist's work and hypotheses on a martian geologic topic**	**Engaging in Argument from Evidence:** Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. **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). Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts. **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. The certainty and durability of science findings varies. Science findings are frequently revised and/or reinterpreted based on new evidence.	**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)	**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. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. Science is a way of knowing used by many people, not just scientists.

(L) Teacher Resource. Mars Image Analysis 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) What Can you Tell from a Picture?	**Engage**	**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 dates, not an absolute scale. (MS-ESS1-4)	**Scale, Proportion, and Quantity:** Phenomena that can be observed at one scale may not be observable at another scale.
(D) Student Data Log	**Explore 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. **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. **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:** 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). Integrate qualitative and/or quantitative scientific and/or technical information in written text with	**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. **Systems and System Models:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex 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 carefully considers and evaluates anomalies in data and evidence.

		that contained in media and visual displays to clarify claims and findings. **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. **Scientific Knowledge is Open to Revision in Light of New Evidence:** 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.		
(K & L) Making Measurements Notes & Student Measurement Data Log	**Explore** **Explain**	**Using Mathematics and Computational Thinking:** Use mathematical representations to describe and/or support scientific conclusions and design solutions. Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. **Obtaining, Evaluating, and Communicating Information:** Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	**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 in rates of change and other numerical relationships can provide information about natural and human designed systems. **Scale, Proportion, and Quantity:** Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. Phenomena that can be observed at one scale may not be observable at another scale. **Scientific 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.
(M & N) Establishing a Research Topic of Interest and Background Research	**Explore** **Explain** **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. **Engaging in Argument from Evidence:** Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. **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)	**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. **Systems and System Models:**

		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). Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. **Scientific Knowledge is Open to Revision in Light of New Evidence:** The certainty and durability of science findings varies. Science findings are frequently revised and/or reinterpreted based on new evidence.		Systems may interact with other systems; they may have sub-systems and be a part of larger complex 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. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. Science is a way of knowing used by many people, not just scientists.
(P & Q) Observation Table	**Explore** **Explain**	**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). Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	**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)	**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. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. Science is a way of knowing used by many people, not just scientists. **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 carefully considers and evaluates anomalies in data and evidence.

(R) Choosing a Topic for Research	**Elaborate** **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. **Engaging in Argument from Evidence:** Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. **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). Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts. **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. The certainty and durability of science findings varies. Science findings are frequently revised and/or reinterpreted based on new evidence.	**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 in rates of change and other numerical relationships can provide information about natural and human designed systems. 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. **Systems and System Models:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. **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. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. Science is a way of knowing used by many people, not just scientists. **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 carefully considers and evaluates anomalies in data and evidence.

(M) Teacher Resource. Mars Image Analysis CCSS Alignment (1 of 3)

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: **Reconstruct geologic events using empirical evidence while assuming the laws of nature on Mars are relatively similar to those laws on Earth.**	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **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:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	**Research to Build and Present Knowledge:** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. 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 **Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.	**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. 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.

Common Core State Standards			
Instructional Objective *Students will be able to*	**Math 6**	**Math 7**	**Math 8**
IO1: **Reconstruct geologic events using empirical evidence while assuming the laws of nature on Mars are relatively similar to those laws on Earth.**	**Ratios and Proportional Relationships (6.RP.1, 6.RP.3d):** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. **The Number System (6.NS.2, 6.NS.3):** Fluently divide multi-digit numbers using the standard algorithm. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. **Expressions and Equations (6.EE.2a):** Write, read, and evaluate expressions in which letters stand for numbers. Write expressions that record operations with numbers and with letters standing for numbers. *For example, express the calculation "Subtract y from 5" as 5 – y.*	**Ratios and Proportional Relationships (7.RP.3):** Use proportional relationships to solve multistep ratio and percent problems. *Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.* **The Number System (7.NS.2c, 7.NS.2d):** Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. Apply properties of operations as strategies to multiply and divide rational numbers. Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats.	

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)**
IO2: **Respectfully debate potential Mars geologic history research topics and questions to elicit relevant information, using quantitative and qualitative evidence and scientific reasoning based on personal observations and previous scientists work regarding patterns of change or possible relationships**	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **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:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.		**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. 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.

(M) Teacher Resource. Mars Image Analysis CCSS Alignment (2 of 3)

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 identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning and the laws of nature** **LO1b:** **to use natural laws of relative dating principles to construct the geologic history of a small portion of Mars** **LO1c:** **to construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and relationships found between features**	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **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:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	**Research to Build and Present Knowledge:** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. 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 **Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.	**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. 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.

Common Core State Standards			
Learning Outcomes *Students will demonstrate the measurable abilities*	**Math 6**	**Math 7**	**Math 8**
LO1a: **to identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning and the laws of nature** **LO1c:** **to construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and relationships found between features**	**Ratios and Proportional Relationships (6.RP.1, 6.RP.3d):** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes." Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. **The Number System (6.NS.2, 6.NS.3):** Fluently divide multi-digit numbers using the standard algorithm. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. **Expressions and Equations (6.EE.2a):** Write, read, and evaluate expressions in which letters stand for numbers. Write expressions that record operations with numbers and with letters standing for numbers. *For example, express the calculation "Subtract y from 5" as 5 – y.*	**Ratios and Proportional Relationships (7.RP.3):** Use proportional relationships to solve multistep ratio and percent problems. *Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.* **The Number System (7.NS.2c, 7.NS.2d):** Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. Apply properties of operations as strategies to multiply and divide rational numbers. Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats.	

(M) Teacher Resource. Mars Image Analysis CCSS Alignment (3 of 3)

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)**
LO2a: **to make a claim, supported by obtained evidence and use sound reasoning of systemic patterns in geologic observations of Mars**	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **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:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.		**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. 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.

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)**
LO2b: to generate background research utilizing credible sources as a collection or catalog of previous scientist's work and hypotheses on a martian geologic topic	**Key Ideas and Details:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **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:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.		

(M) Teacher Resource. Mars Image Analysis 21st Century Skills Alignment (1 of 2)

21st Century Skills		
Learning Outcomes *Students will demonstrate the measurable abilities*	**21st Century Skill**	**Grade 8 Benchmark**
LO1a: to identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning and the laws of nature	**Collaboration**	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Social and Cross-Cultural Skills	Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
LO1b: to use natural laws of relative dating principles to construct the geologic history of a small portion of Mars	**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.
LO1c: to construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and 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.
	Critical Thinking and Problem Solving	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.
	Collaboration	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Media Literacy	Students are able to identify and critique arguments in which the claims are not consistent with the evidence given.
	Social and Cross-Cultural Skills	Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.

(M) Teacher Resource. Mars Image Analysis 21st Century Skills Alignment (2 of 2)

21st Century Skills

Learning Outcomes *Students will demonstrate the measurable abilities*	21st Century Skill	Grade 8 Benchmark
LO2a: **to make a claim, supported by obtained evidence and use sound reasoning of systemic patterns in geologic observations of Mars**	**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.
	Critical Thinking and Problem Solving	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.
	Collaboration	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Media Literacy	Students are able to identify and critique arguments in which the claims are not consistent with the evidence given.
	Flexibility and Adaptability	Students can identify the difference between scientific theories (which can be improved through new evidence and expanded through exceptions to observed patterns) and beliefs (which may or may not be based on evidence).
	Social and Cross-Cultural Skills	Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
LO2b: **to generate background research utilizing credible sources as a collection or catalog of previous scientist's work and hypotheses on a martian geologic topic**	**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.
	Flexibility and Adaptability	Students can identify the difference between scientific theories (which can be improved through new evidence and expanded through exceptions to observed patterns) and beliefs (which may or may not be based on evidence).
	Leadership and Responsibility	Students understand the importance of proper citations and respect for intellectual property rights.

(N) Teacher Resource. Mars Image Analysis 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 identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning and the laws of nature	Geologic feature identifications are logical and supported by evidence	Geologic features are logical and somewhat supported by evidence	Geologic features are reasonably logical and somewhat supported by evidence	Geologic features are illogical and/or not supported by evidence
LO1b: to use natural laws of relative dating principles to construct the geologic history of a small portion of Mars	Geologic sequences are logical and supported by relative age dating principles	Geologic sequences are logical and somewhat supported by relative age dating principles	Geologic sequences are reasonably logical and somewhat supported relative age dating principles	Geologic sequences are illogical and/or not supported by relative age dating principles
LO1c: to construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and relationships found between features	Geologic sequences are logical and supported by evidence	Geologic sequences are logical and somewhat supported by evidence	Geologic sequences are reasonably logical and somewhat supported by evidence	Geologic sequences are illogical and/or not supported by evidence
LO2a: to make a claim, supported by obtained evidence and use sound reasoning of systemic patterns in geologic observations of Mars	THEMIS observations include drawings and scientific claims of feature type and formation, supported by evidence provided by the site and lesson, includes a detailed explanation of how this is evidence for the type of formation. Presents a potential topic of interest to the team including the compelling evidence and reasoning from background research. Effectively shares ideas during collaboration and listens to ideas before providing constructive feedback.	THEMIS observations include drawings and scientific claims of feature type and formation, supported by evidence provided by the site or lesson, includes an explanation of how this is evidence for the type of formation. Presents a potential topic of interest to the team including the compelling evidence and reasoning from background research. May shares ideas during collaboration and listen to ideas, but may have difficulty with constructive feedback to ideas.	THEMIS observations include a drawing and labeling of the feature. Uses evidence from the site or lesson for feature identification. Shares a number of ideas with the group but may not connect to evidence and reasoning of background research. May or may not fully listen to ideas and/or provide constructive feedback.	THEMIS observations include a drawing and labeling of the feature. Sharing of ideas is limited to a neighbor or written form only. Allows the group to make the decision.

LO2b: to generate background research utilizing credible sources as a collection or catalog of previous scientist's work and hypotheses on a martian geologic topic	Evaluate all sources for credibility and use informational text to develop a detailed summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.	Evaluate most sources for credibility and use informational text to develop a detailed summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.	Some sources are credibility and uses informational text to develop a brief summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.	May use credible text to develop a brief summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.

(N) Teacher Resource. Mars Image Analysis CCSS Rubric (2 of 3)

Common Core – ELA & Math

	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 and background research on those features.	Develops strong, geologic vocabulary through feature identification and background research on those features.	Develops vocabulary through feature identification.	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 deep 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 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.

Ratios and Proportional Relationships, The Number System & Expressions and Equations	Correctly solves for scale factor (proportion), applies the scale factor to a wide range of features in the THEMIS image to solve for km, and clearly demonstrates an understanding that the scale factor demonstrates the relationship between the measured size of a feature in the image and the actual size of the feature on the planet.	Correctly solves for scale factor (proportion) and applies the scale factor to a wide range of features in the THEMIS image to solve for km demonstrating the relationship between the measured size of a feature in the image and the actual size of the feature on the planet.	Solves for scale factor (proportion) and applies the scale factor to a wide range of features in the THEMIS image to solve for km with support from teacher and peers.	Attempts to solve for scale factor, transposing the numerator and denominator and/or using rounded measurements instead of decimals.

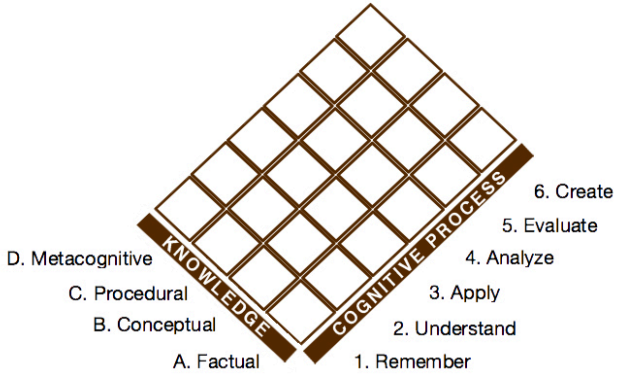
(L) Teacher Resource. Mars Image Analysis 21st Century Skills Rubric (3 of 3)

Partnership for 21st Century Skills

	Expert	Proficient	Intermediate	Beginner
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.
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 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	Table is an excellent representation of a wide variety of observations, questions, and explanations of ideas using credible evidence from scientific theories.	Table represents observations, questions, and/or explanations. Most explanations are based on evidence with few, if any on personal belief.	Table represents observations and explanations based on a mixture of evidence and personal belief.	Table represents an observation and an explanation based on personal belief.

(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.



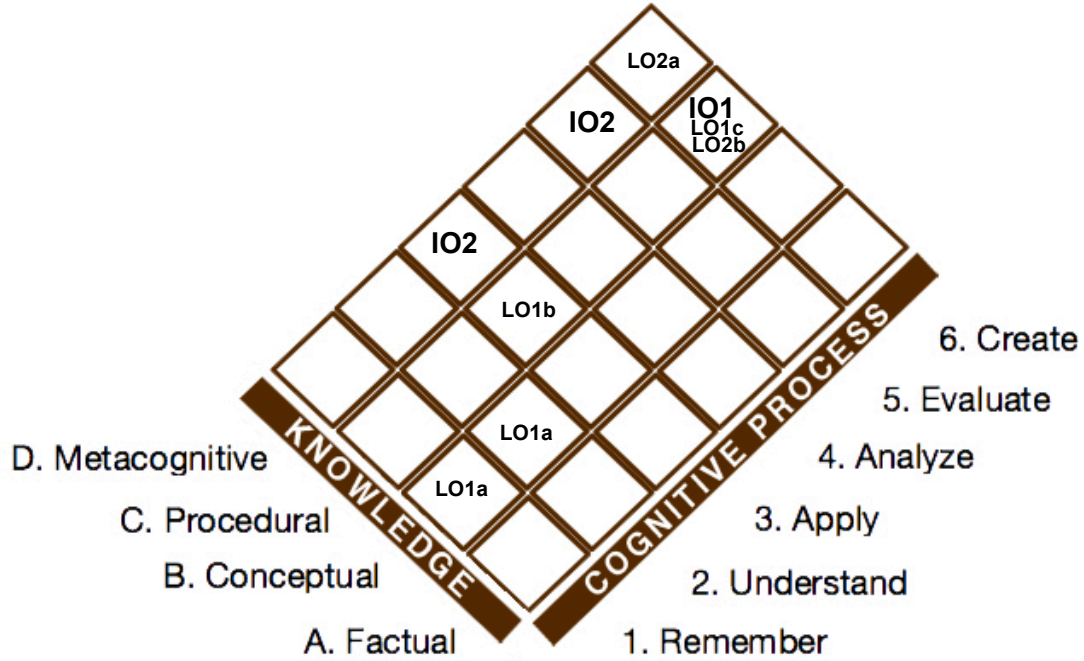
Knowledge	Cognitive Process
A. Factual **Aa:** Knowledge of Terminology **Ab:** Knowledge of Specific Details & Elements **B. Conceptual** **Ba:** Knowledge of classifications and categories **Bb:** Knowledge of principles and generalizations **Bc:** Knowledge of theories, models, and structures **C. 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: **to reconstruct** geologic events using empirical evidence while assuming the laws of nature on Mars are relatively similar to those laws on Earth. (6.3; Cb)

LO1a. to identify, analyze, and interpret geologic features in a THEMIS image using scientific reasoning and the laws of nature (1.1, 2.1; Ba)
LO1b. to use natural laws of relative dating principles to construct the geologic history of a small portion of Mars (3.2; Cb)
LO1c. to construct an explanation of the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis on the patterns and relationships found between features (6.3; Cb)



IO2: **to** respectfully **debate** potential Mars geologic history research topics and questions to elicit relevant information, **using** quantitative and qualitative evidence and scientific reasoning based on personal observations and previous scientists work regarding patterns of change or possible relationships (5.2, 3.2; Da)

LO2a. to make a claim, supported by obtained evidence and **use** sound reasoning of systemic patterns in geologic observations of Mars (6.1; Da)
LO2b. to generate background research utilizing credible sources as a collection or catalog of previous scientist's work and hypotheses on a martian geologic topic (6.1; 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 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 previous pages for the full list of categories in the taxonomy from which the following were selected. The prior page 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 reconstruct geologic events using empirical evidence
- **6.3:** to construct
- **Cb:** knowledge of subject-specific techniques and methods

IO2: to debate and use empirical evidence
- **5.2:** to critique
- **3.2:** to use
- **Da:** strategic knowledge

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

LO1a: to identify analyze, and interpret geologic features in a THEMIS image
- 1.1: to identify
- 2.1: to interpret
- Ba: knowledge of classifications and categories

LO1b: to use natural laws
- 3.2: to use
- Cb: knowledge of subject-specific techniques and methods

LO1c: to construct an explanations using empirical evidence
- 6.3: to construct
- Cb: knowledge of subject-specific techniques and methods

LO2a: to make a claim, using evidence and reasoning in observations
- 6.1: to generate
- Da: strategic knowledge

LO2b. to generate background research from credible sources
- 6.1: to generate
- Cb: knowledge of subject-specific techniques and methods