Mars Image Analysis

High 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.

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

How do Earth's major systems interact?

NRC ESS2.A: Earth Materials and Systems

INSTRUCTIONAL OBJECTIVES

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 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.**

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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

How do Earth's major systems interact?

NRC ESS2.A: Earth Materials and Systems

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 at different scales in a THEMIS image using scientific reasoning and the laws of nature **LO1b.** to use natural laws of geologic processes, such as plate tectonics and erosion, to collaboratively construct the geologic history of a variety of features at differing scales 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** (HS-ESS1-6) **ESS2.A: Earth Materials and Systems** (HS-ESS2-1; HS-ESS2-2) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes** (HS-ESS2-5) **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 Based on Empirical Evidence** **Scientific Knowledge is Open to Revision in Light of New Evidence** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**
IO2: Respectfully debate potential Mars geologic history research topics and questions to elicit relevant information, using quantitative and qualitative	**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 collection or catalog of previous	**CROSSCUTTING CONCEPTS:** 1. Patterns 2. Cause and Effect: Mechanism and Prediction 3. Scale, Proportion and Quantity 4. Structure and Function 5. Stability and Change **Science is a Way of Knowing** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

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evidence and scientific reasoning based on personal observations and previous scientists work regarding patterns of change or possible relationships.	**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:
(HS-ESS1-6); (HS-ESS2-1; HS-ESS2-2; HS-ESS2-5)

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 and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.

(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, or unexpected results, to clarify and/or seek additional information. Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships. Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. Ask questions to clarify and refine a model, an explanation, or an engineering problem. **Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Constructing Explanations and Designing Solutions:** Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence:**	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Cause and Effect: Mechanism and Prediction:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Scale, Proportion, and Quantity:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales.

	Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.		**Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific is a Way of Knowing:** Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge. Science is a unique way of knowing and there are other ways of knowing. Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review. Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.

(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 at different scales 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:** Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. **Using Mathematics and Computational Thinking:** Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). **Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Patterns:** Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Scale, Proportion, and Quantity:** Patterns observable at one scale may not be observable or exist at other scales. **Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.

	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 provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence:** Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.		
LO1b: **to use natural laws of geologic processes, such as plate tectonics and erosion, to collaboratively construct the geologic history of a variety of features at differing scales of a small portion of Mars**	**Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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:** Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:**	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Scale, Proportion, and Quantity:** Patterns observable at one scale may not be observable or exist at other

	additional information is required to resolve contradictions. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. **Scientific Knowledge is Open to Revision in Light of New Evidence** Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	scales. **Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Stability and Change:** Much of science deals with constructing explanations of how things change and how they remain stable. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.
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**	**Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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 or counter-arguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. **Obtaining, Evaluating, and Communicating**	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Cause and Effect: Mechanism and Prediction:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

	Information: Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. **Scientific Knowledge is Open to Revision in Light of New Evidence** Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Scale, Proportion, and Quantity:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales. **Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Stability and Change:** Much of science deals with constructing explanations of how things change and how they remain stable. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.

(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**	**Analyzing and Interpreting Data:** Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. **Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Constructing Explanations and Designing Solutions:** Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence:** Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's	**Patterns:** Mathematical representations are needed to identify some patterns. Empirical evidence is needed to identify patterns. **Cause and Effect:** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Scale, Proportion, and Quantity:** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Stability and Change:** Much of science deals with constructing explanations of how things change and how

	Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based on empirical evidence. Science includes the process of coordinating patterns of evidence with current theory. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	they remain stable. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.
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 evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and	**Science is a Way of Knowing:** Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge. Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.

	reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems. **Scientific Knowledge is Open to Revision in Light of New Evidence:** Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that has been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	

(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, or unexpected results, to clarify and/or seek additional information.	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's	**Scale, Proportion, and Quantity:** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales.

			surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	
(D) Student Data Log	**Explore** **Explain**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. **Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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 reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence:** Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. Mathematical representations are needed to identify some patterns. Empirical evidence is needed to identify patterns. **Cause and Effect: Mechanism and Prediction** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system **Scale, Proportion, and Quantity:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be

		Obtaining, Evaluating, and Communicating Information: Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Scientific Knowledge is Open to Revision in Light of New Evidence:** Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	observable or exist at other scales. **Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.
(K & L) Making Measurements Notes & Student Measurement Data Log	**Explore** **Explain**	**Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems.	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)	**Patterns:** Mathematical representations are needed to identify some patterns. **Scientific is a Way of Knowing:** Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.

		Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).	**ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	
(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, or unexpected results, to clarify and/or seek additional information. **Engaging in Argument from Evidence:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2)	**Cause and Effect: Mechanism and Prediction** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Scale, Proportion, and Quantity:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales.

		additional information is required to resolve contradictions. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Scientific Knowledge is Open to Revision in Light of New Evidence:** Science includes the process of coordinating patterns of evidence with current theory.	***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Science is a Way of Knowing:** Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.

		Science arguments are strengthened by multiple lines of evidence supporting a single explanation.		
(P & Q) Observation Table	**Explore** **Explain**	**Obtaining, Evaluating, and Communicating Information:** Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Scale, Proportion, and Quantity:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.

(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. **Constructing Explanations and Designing Solutions:** Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. **Engaging in Argument from Evidence:** Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Communicate scientific and/or technical	**ESS1.C: The History of Planet Earth:** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2) ***Either of the following:** **ESS2.B: Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes:** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)	**Cause and Effect: Mechanism and Prediction** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.

		information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Scientific Evidence is Based on Empirical Evidence:** Science knowledge is based on empirical evidence. Science arguments are strengthened by multiple lines of evidence supporting a single explanation. **Scientific Knowledge is Open to Revision in Light of New Evidence:** Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation		

(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**	**Writing Standards for Literacy in Science and Technical Subjects**	**Speaking and Listening Standards**
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:** **Grades 9-10:** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them. **Grades 11-12:** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.	**Production and Distribution of Writing:** **Grades 9-10:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. **Grades 11-12:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. **Research to Build and Present Knowledge:** **Grades 9-10:** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. Draw evidence from informational texts to support analysis, reflection, and research. **Grades 11-12:** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.	**Comprehension and Collaboration:** **Grades 9-10:** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious

	Craft and Structure: **Grades 9-10:** Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies. **Grades 11-12:** Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10). **Integration of Knowledge and Ideas:** **Grades 9-10:** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text. Compare and contrast treatments of the same topic in several primary and secondary sources. **Grades 11-12:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	Draw evidence from informational texts to support analysis, reflection, and research.	reasoning or exaggerated or distorted evidence. **Grades 11-12:** Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

Common Core State Standards			
Instructional Objective *Students will be able to*	**Reading Standards for Literacy in Science and Technical Subjects**	**Writing Standards for Literacy in Science and Technical Subjects**	**Speaking and Listening Standards**
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:** **Grades 9-10:** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them. **Grades 11-12:** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain. **Craft and Structure:** **Grades 9-10:** Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies. **Grades 11-12:** Determine the meaning of words and phrases as		**Comprehension and Collaboration:** **Grades 9-10:** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence. **Grades 11-12:** Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and

	they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10). **Integration of Knowledge and Ideas:** **Grades 9-10:** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text. Compare and contrast treatments of the same topic in several primary and secondary sources. **Grades 11-12:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.		expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **Presentation of Knowledge and Ideas:** **Grades 9-10:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. **Grades 11-12:** Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

(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**	**Writing Standards for Literacy in Science and Technical Subjects**	**Speaking and Listening Standards**
LO1a: **to identify, analyze, and interpret geologic features at different scales in a THEMIS image using scientific reasoning and the laws of nature** **LO1b:** **to use natural laws of geologic processes, such as plate tectonics and erosion, to collaboratively construct the geologic history of a variety of features at differing scales of a small portion of Mars**	**Key Ideas and Details:** **Grades 9-10:** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them. **Grades 11-12:** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.		**Comprehension and Collaboration:** **Grades 9-10:** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. Evaluate a speaker's point of view, reasoning, and

	Craft and Structure: **Grades 9-10:** Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies. **Grades 11-12:** Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10). **Integration of Knowledge and Ideas:** **Grades 9-10:** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text. Compare and contrast treatments of the same topic in several primary and secondary sources. **Grades 11-12:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.		use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence. **Grades 11-12:** Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

Common Core State Standards			
Learning Outcomes *Students will demonstrate the measurable abilities*	**Reading Standards for Literacy in Science and Technical Subjects**	**Writing Standards for Literacy in Science and Technical Subjects**	**Speaking and Listening Standards**
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:** **Grades 9-10:** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them. **Grades 11-12:** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain. **Craft and Structure:** **Grades 9-10:** Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies. **Grades 11-12:** Determine the meaning of words and phrases as	**Production and Distribution of Writing:** **Grades 9-10:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. **Grades 11-12:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. **Research to Build and Present Knowledge:** **Grades 9-10:** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. Draw evidence from informational texts to support analysis, reflection, and research. **Grades 11-12:** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. Draw evidence from informational texts to support analysis, reflection, and research.	**Comprehension and Collaboration:** **Grades 9-10:** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.

	they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10). **Integration of Knowledge and Ideas:** **Grades 9-10:** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text. Compare and contrast treatments of the same topic in several primary and secondary sources. **Grades 11-12:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.		**Grades 11-12:** Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

(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**	**Writing Standards for Literacy in Science and Technical Subjects**	**Speaking and Listening Standards**
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:** **Grades 9-10:** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them. **Grades 11-12:** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain. **Craft and Structure:** **Grades 9-10:** Determine the meaning of words and phrases as they are used in a text, including vocabulary		**Comprehension and Collaboration:** **Grades 9-10:** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence. **Grades 11-12:** Initiate and participate effectively in a range of collaborative

	describing political, social, or economic aspects of history/social studies. **Grades 11-12:** Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10). **Integration of Knowledge and Ideas:** **Grades 9-10:** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text. Compare and contrast treatments of the same topic in several primary and secondary sources. **Grades 11-12:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.		discussions (one-on- one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **Presentation of Knowledge and Ideas:** **Grades 9-10:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. **Grades 11-12:** Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

Common Core State Standards			
Learning Outcomes *Students will demonstrate the measurable abilities*	**Reading Standards for Literacy in Science and Technical Subjects**	**Writing Standards for Literacy in Science and Technical Subjects**	**Speaking and Listening Standards**
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:** **Grades 9-10:** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text. Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them. **Grades 11-12:** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain. **Craft and Structure:** **Grades 9-10:** Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies.		

	Grades 11-12: Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10). **Integration of Knowledge and Ideas:** **Grades 9-10:** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text. Compare and contrast treatments of the same topic in several primary and secondary sources. **Grades 11-12:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.		

(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 12 Benchmark
LO1a: **to identify, analyze, and interpret geologic features at different scales in a THEMIS image using scientific reasoning and the laws of nature**	**Collaboration**	Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.
	Flexibility and Adaptability	Students are able to revise their own scientific ideas and hypotheses based on new evidence or information.
LO1b: **to use natural laws of geologic processes, such as plate tectonics and erosion, to collaboratively construct the geologic history of a variety of features at differing scales of a small portion of Mars**	**Communication**	Students model the practices of research science by informing others about their work, developing effective explanations, constructing and defending reasoned arguments, and responding appropriately to critical comments about their explanations.
	Flexibility and Adaptability	Students are able to successfully apply their scientific knowledge and scientific reasoning skills to a variety of situations and new areas of study.
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**	**Communication**	Students model the practices of research science by informing others about their work, developing effective explanations, constructing and defending reasoned arguments, and responding appropriately to critical comments about their explanations.
	Collaboration	Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.
	Flexibility and Adaptability	Students are able to revise their own scientific ideas and hypotheses based on new evidence or information.

(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 12 Benchmark**
LO2a: to make a claim, supported by obtained evidence and use sound reasoning of systemic patterns in geologic observations of Mars	**Communication**	Students model the practices of research science by informing others about their work, developing effective explanations; constructing and defending reasoned arguments, and responding appropriately to critical comments about their explanations.
	Collaboration	Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.
	Flexibility and Adaptability	Students are able to revise their own scientific ideas and hypotheses based on new evidence or information.
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	**Creativity and Innovation**	Students explain how scientific understanding builds on itself over time, and how advancements in science depend on creative thinking based on the knowledge and innovations of others.

(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 at different scales 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 geologic processes, such as plate tectonics and erosion, to collaboratively construct the geologic history of a variety of features at differing scales 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	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	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	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.

	including the compelling evidence and reasoning from background research. Effectively shares ideas during collaboration and listens to ideas before providing constructive feedback.	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.	not fully listen to ideas and/or provide constructive feedback.	
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

	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.

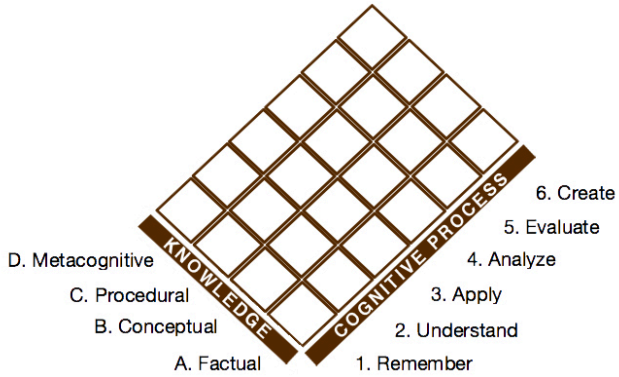
(L) Teacher Resource. Mars Image Analysis 21st Century Skills Rubric (3 of 3)

Partnership for 21st Century Skills

	Expert	Proficient	Intermediate	Beginner
Effectiveness 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 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.
Effective of Communication	Communicates ideas in a clearly organized and logical manner that is consistently maintained.	Communicates ideas in an organized manner that is consistently maintained.	Communications of ideas are organized, but not consistently maintained.	Communicates ideas as they come to mind.

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

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



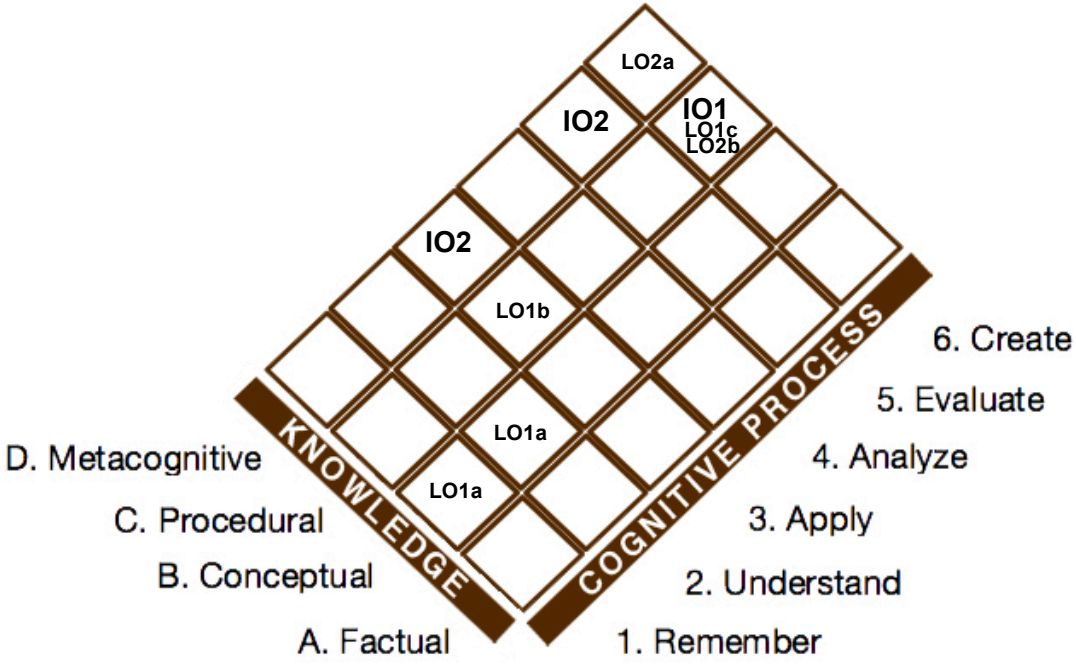
Knowledge	Cognitive Process
A. Factual **Aa:** Knowledge of Terminology **Ab:** Knowledge of Specific Details & Elements **B. Conceptual** **Ba:** Knowledge of classifications and categories **Bb:** Knowledge of principles and generalizations **Bc:** Knowledge of theories, models, and structures **C. Procedural** **Ca:** Knowledge of subject-specific skills and algorithms **Cb:** Knowledge of subject-specific techniques and methods **Cc:** Knowledge of criteria for determining when to use appropriate procedures **D. Metacognitive** **Da:** Strategic Knowledge **Db:** Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge **Dc:** Self-knowledge	**1. Remember** **1.1** Recognizing (Identifying) **1.2** Recalling (Retrieving) **2. Understand** **2.1** Interpreting (Clarifying, Paraphrasing, Representing, Translating) **2.2** Exemplifying (Illustrating, Instantiating) **2.3** Classifying (Categorizing, Subsuming) **2.4** Summarizing (Abstracting, Generalizing) **2.5** Inferring (Concluding, Extrapolating, Interpolating, Predicting) **2.6** Comparing (Contrasting, Mapping, Matching) **2.7** Explaining (Constructing models) **3. Apply** **3.1** Executing (Carrying out) **3.2** Implementing (Using) **4. Analyze** **4.1** Differentiating (Discriminating, Distinguishing, Focusing, Selecting) **4.2** Organizing (Finding coherence, Integrating, Outlining, Parsing, Structuring) **4.3** Attributing (Deconstructing) **5. Evaluate** **5.1** Checking (Coordinating, Detecting, Monitoring, Testing) **5.2** Critiquing (Judging) **6. Create** **6.1** Generating (Hypothesizing) **6.2** Planning (Designing) **6.3** Producing (Constructing)

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

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 at different scales in a THEMIS image using scientific reasoning and the laws of nature (1.1, 2.1; Ba)
LO1b. to use natural laws of geologic processes, such as plate tectonics and erosion, to collaboratively construct the geologic history of a variety of features at differing scales 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