

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	INSTRUCTIONAL OBJECTIVES	
WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT?	Students will be able to:	
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?	IO1: Reconstruct geologic events using empirical evidence while assuming the laws of nature or Mars are relatively similar to those laws on Earth.	
NRC ESS2.A: Earth Materials and Systems	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 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	 Patterns Cause and Effect: Mechanism and Prediction Scale, Proportion and Quantity Structure and Function Stability and Change Science is a Way of Knowing Scientific Knowledge Assumes an Order and Consistency in Natural Systems 		

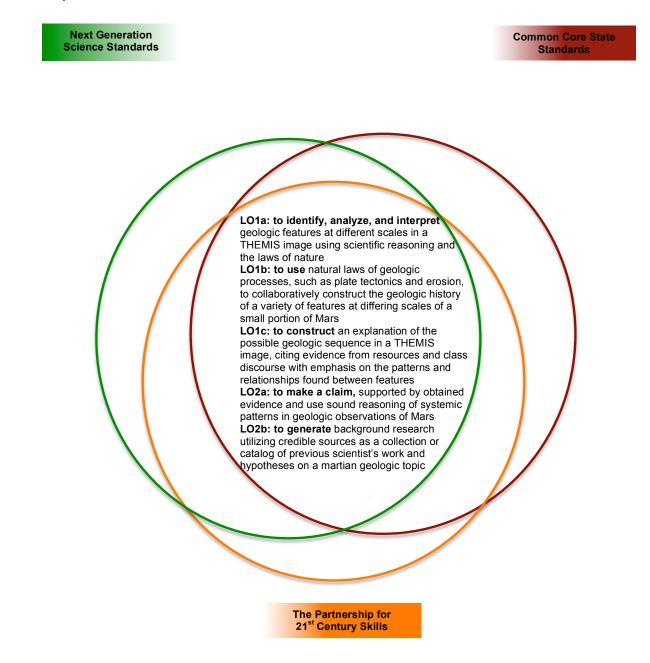


-		scientist's work and hypotheses on a martian geologic topic		
	patterns of change or possible			



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.





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 twentysix 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)

Instructional Objective Students will be able to	Science and Engineering Practices Constructing Explanations	Disciplinary Core Idea ESS1.C: The History of Planet Earth:	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.	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.	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: 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. (<i>ESS2.B Grade 8 GBE</i>) (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 metting points of rocks. (HS-ESS2-5)	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.



Teacher Guide

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

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.	 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 ca 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 ca be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scal mechanisms within the system. Scale, Proportion, and Quantit The significance of a phenomenon is dependent on the scale, proportion, and quantity at which occurs. Some systems can only be studie indirectly as they are too small, to large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist a other scales.





Teacher Guide

(L) Teacher Resource. Mars Image Analysis NGSS Alignment (2 of 3)

Learning Outcomes Science and Engineering Practices Disciplinary Core Idea Crosscutting Conce Students will demonstrate the measurable abilities Asking Questions and Defining Problems: ESS1.C: The History of Planet Earth: Patterns:	Next Generation Science Standards Alignment (NGSS)			
Asking Questions and Defining Problems: ESS1.C: The History of Planet Earth: Patterns: Patterns:	emonstrate Science and E	Crosscutting Concepts		
 to identify, analyze, and interpret geologic features at different scales in a THEMIS image using scientific reasoning and the laws of nature Consider limitations of data analysis (e.g., measurement problems involving and interpreting data. Sets (e.g., self-generated, archival) to examine consistency of measurements and observations to represent and solve scientific and engineering problems. 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: 	 Ask questions that i observation of pherule inexpected results, additional information of additional information. Analyzing and International information of analyzing and international information of analyzing and international information. Analyzing and International information of analyzing and international information of analyzing and international information of analyzing and international information. Analyzing and International information of analyzing and international information of analyzing and international information of analyzing and international information. Using Mathematic Thinking: Apply techniques or represent and solve problems. Apply ratios, rates, conversions in the or measurement problem with derived or commismum. kg/m3, acrematic on struct and revise valid and reliable evariety of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer review) and the struct of sources (investigations, mod peer	tectonics very early tem, such unged little rovide ry. (HS-Classifications or explanations used at one scale may fail or need revision when information from smaller or larged scales is introduced; thus requiring improved investigations and experiments.use originalScale, Proportion, and Quantity: Patterns observable at one scale may not be observable or exist at other scales.use originalScale, Proportion, and Quantity: Patterns observable or exist at other scales.use originalScale, Proportion, and Quantity: Patterns 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.Processes: und its elease upon er theScience assumes the universe is a vas single system in which basic laws are consistent.		

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	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.		
	contradictions.		
	Construct, use, and/or present an oral and		
	written argument or counter-arguments based		
	on data and evidence.		
	Make and defendent states in a state of an		
	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.		Detterme
	Constructing Explanations and Designing	ESS1.C: The History of Planet Earth:	Patterns:
LO1b:	Solutions:	Although active geologic processes, such as plate tectonics	Different patterns may be observed at
to use natural laws	Construct and revise an explanation based on	and erosion, have destroyed or altered most of the very early	each of the scales at which a system is
of geologic	valid and reliable evidence obtained from a	rock record on Earth, other objects in the solar system, such	studied and can provide evidence for
processes, such as	variety of sources (including students' own	as lunar rocks, asteroids, and meteorites, have changed little	causality in explanations of
plate tectonics and	investigations, models, theories, simulations, peer review) and the assumption that theories	over billions of years. Studying these objects can provide	phenomena.
erosion, to	· · · · ·	information about Earth's formation and early history. (HS-	Classifications or evaluations used at
collaboratively	and laws that describe the natural world	ESS1-6)	Classifications or explanations used at one scale may fail or need revision
_	operate today as they did in the past and will	ESS2 A. Earth Matariala and Systema	
construct the	continue to do so in the future.	ESS2.A: Earth Materials and Systems:	when information from smaller or larger
geologic history of	Engaging in Argument from Evidence	Earth's systems, being dynamic and interacting, cause	scales is introduced; thus requiring
a variety of	Engaging in Argument from Evidence:	feedback effects that can increase or decrease the original	improved investigations and
features at	Respectfully provide and/or receive critiques	changes. (HS-ESS2-1),(HS-ESS2-2)	experiments.
differing scales of	on scientific arguments by probing reasoning	*Either of the following:	Saala Branartian and Quantitur
a small portion of	and evidence and challenging ideas and	*Either of the following:	Scale, Proportion, and Quantity:
Mars	conclusions, responding thoughtfully to		Patterns observable at one scale may
	diverse perspectives, and determining what		not be observable or exist at other



	additional information is required to resolve	ESS2.B: Plate Tectonics and Large-Scale System	scales.
	contradictions.	Interactions:	
		Plate tectonics is the unifying theory that explains the past and	Structure and Function:
	Make and defend a claim based on evidence	current movements of the rocks at Earth's surface and	The functions and properties of natural
	about the natural world or the effectiveness of	provides a framework for understanding its geologic history.	and designed objects and systems can
	a design solution that reflects scientific	Plate movements are responsible for most continental and	be inferred from their overall structure,
	knowledge, and student-generated evidence.	ocean-floor features and for the distribution of most rocks and	the way their components are shaped
		minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-	and used, and the molecular
	Scientific Knowledge is Open to Revision	ESS2-1)	substructures of its various materials.
	in Light of New Evidence		
	Scientific argumentation is a mode of logical	ESS2.C: The Roles of Water in Earth's Surface Processes:	Stability and Change:
	discourse used to clarify the strength of	The abundance of liquid water on Earth's surface and its	Much of science deals with constructing
	relationships between ideas and evidence that	unique combination of physical and chemical properties are	explanations of how things change and
	may result in revision of an explanation.	central to the planet's dynamics. These properties include	how they remain stable.
	may result in revision of an explanation.	water's exceptional capacity to absorb, store, and release	new mey remain stable.
		large amounts of energy, transmit sunlight, expand upon	Scientific Knowledge Assumes an
		freezing, dissolve and transport materials, and lower the	Order and Consistency in Natural
		viscosities and melting points of rocks. (HS-ESS2-5)	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.
	Constructing Explanations and Designing	ESS1.C: The History of Planet Earth:	Patterns:
LO1c:	Solutions:	Although active geologic processes, such as plate tectonics	Different patterns may be observed at
to construct an	Construct and revise an explanation based on	and erosion, have destroyed or altered most of the very early	each of the scales at which a system is
explanation of the	valid and reliable evidence obtained from a	rock record on Earth, other objects in the solar system, such	studied and can provide evidence for
possible geologic	variety of sources (including students' own	as lunar rocks, asteroids, and meteorites, have changed little	causality in explanations of
sequence in a	investigations, models, theories, simulations,	over billions of years. Studying these objects can provide	phenomena.
-	peer review) and the assumption that theories	information about Earth's formation and early history. (HS-	
THEMIS image	and laws that describe the natural world	ESS1-6)	Classifications or explanations used at
citing evidence	operate today as they did in the past and will		one scale may fail or need revision
from resources and	continue to do so in the future.	ESS2.A: Earth Materials and Systems:	when information from smaller or larger
class discourse		Earth's systems, being dynamic and interacting, cause	scales is introduced; thus requiring
with emphasis on	Engaging in Argument from Evidence:	feedback effects that can increase or decrease the original	improved investigations and
the patterns and	Construct, use, and/or present an oral and	changes. (HS-ESS2-1),(HS-ESS2-2)	experiments.
relationships found	written argument or counter-arguments based		
-	on data and evidence.	*Either of the following:	Cause and Effect: Mechanism and
between features			Prediction:
	Make and defend a claim based on evidence	ESS2.B: Plate Tectonics and Large-Scale System	Cause and effect relationships can be
	about the natural world or the effectiveness of	Interactions:	suggested and predicted for complex
	a design solution that reflects scientific	Plate tectonics is the unifying theory that explains the past and	natural and human designed systems
	knowledge, and student-generated evidence.	current movements of the rocks at Earth's surface and	by examining what is known about
		provides a framework for understanding its geologic history.	smaller scale mechanisms within the
	Obtaining, Evaluating, and Communicating		system.



Information:Plate movements are responsible for most continential and concentions 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.Plate movements are responsible for most continential and cosen-floor features and for the distribution of most rocks and ESS2-1)Scientific And/or technical information, or summarize complex evidence, concepts, processes, or intogramment to its and evidence that may result in revision of an explanation.Plate movements are responsible for most continential and cosensition of physical and chemical properties and technical independent on the scale, proportion, and quantity at which it occurs.Scientific Xnowledge 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 continential and cosen-floor integrities include target no text at other scientific and/or of an explanation.Scientific Anowledge is Open to Revision text and the distribution of an explanation.Scientific Anowledge is Descientific and/or text and/or text and/or text and/or text and wert the planet's dynamical is and ower the vision 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 containent and constructing text and were the splanation.Scientific Anowledge Scientific Anowledge Assumes an text at other scientific Anowledge is based on the asubgrutures of its various materials.Scient
Science assumes the universe is a vast single system in which basic laws are



Teacher Guide

(L) Teacher Resource. Mars Image Analysis NGSS Alignment (2 of 3)

Next Generat	ion 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. (<i>ESS2.B Grade 8 GBE</i>) (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

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	Make and defend a claim based on evidence about	exceptional capacity to absorb, store, and release	they remain stable.
	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.	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.
	Engaging in Argument from Evidence:	ESS1.C: The History of Planet Earth:	Science is a Way of Knowing:
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	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.	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: 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. (<i>ESS2.B: Grade 8 GBE</i>) (HS-ESS2-1) ESS2.C: The Roles of Water in Earth's Surface	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.
	Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media	Processes: The abundance of liquid water on Earth's surface and its unique combination of physical and	16



reports, verifying the data when possible.	chemical properties are central to the planet's	
	dynamics. These properties include water's	
Communicate scientific and/or technical information	exceptional capacity to absorb, store, and release	
or ideas (e.g. about phenomena and/or the process of	large amounts of energy, transmit sunlight, expand	
development and the design and performance of a	upon freezing, dissolve and transport materials,	
proposed process or system) in multiple formats	and lower the viscosities and melting points of	
(including orally, graphically, textually, and	rocks. (HS-ESS2-5)	
mathematically).	· · · · · · · · · · · · · · · · · · ·	
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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.		
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Teacher Guide

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

	Phases of			
Activity	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: 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. <i>(ESS2.B Grade 8 GBE)</i> (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.

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



			have a sector standard and a second because the second second second second second second second second second	
		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	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.
		relationships between ideas and evidence that may result in revision of an explanation.		
(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	ESS2.A: Earth Materials and Systems:	
		conversions in the context of complicated	Earth's systems, being dynamic and	
		measurement problems involving quantities	interacting, cause feedback effects that can	
		with derived or compound units (such as	increase or decrease the original changes.	
		mg/mL, kg/m3, acre-feet, etc.).	(HS-ESS2-1),(HS-ESS2-2)	
		3 , 3 ., , ,		
			*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)	
			(113-2332-1)	
			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)	· · · · · · · · · · · · · · · · · · ·
		Asking Questions and Defining Problems:	ESS1.C: The History of Planet Earth:	Cause and Effect: Mechanism and
		Ask questions that arise from careful	Although active geologic processes, such as	Prediction
		observation of phenomena, or unexpected	plate tectonics and erosion, have destroyed or	Empirical evidence is required to differentiate
		results, to clarify and/or seek additional	altered most of the very early rock record on	between cause and correlation and make
		information.	Earth, other objects in the solar system, such	claims about specific causes and effects.
(M & N)		Encoder in Annual from Ender	as lunar rocks, asteroids, and meteorites,	Cools Dranartian and Countilla
Establishing a	F	Engaging in Argument from Evidence:	have changed little over billions of years.	Scale, Proportion, and Quantity:
Research Topic	Explore	Evaluate the claims, evidence, and/or	Studying these objects can provide	The significance of a phenomenon is
of Interest and	Explain	reasoning behind currently accepted	information about Earth's formation and early	dependent on the scale, proportion, and
Background	Elaborate	explanations or solutions to determine the	history. (HS-ESS1-6)	quantity at which it occurs.
Research		merits of arguments.		
nescarti			ESS2.A: Earth Materials and Systems:	Some systems can only be studied indirectly
		Respectfully provide and/or receive critiques	Earth's systems, being dynamic and	as they are too small, too large, too fast, or
		on scientific arguments by probing reasoning	interacting, cause feedback effects that can	too slow to observe directly.
		and evidence and challenging ideas and	increase or decrease the original changes.	
		conclusions, responding thoughtfully to	(HS-ESS2-1),(HS-ESS2-2)	Patterns observable at one scale may not be
		diverse perspectives, and determining what		observable or exist at other scales.
				01



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



		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 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.

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(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	 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 and is 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.
				24
				24



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).	
mainemailcaily).	
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.	
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	



Teacher Guide

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

Common	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; 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. 		

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



Common Core State Standards

Information, using qualitative avidnesdraw on that preparation by referring to evidence from texts and other research on th topic or issue to stimulate a thoughtful, well- reasoned exchange of ideas.and scientific reasoning based on personal observations and previous scientists work regarding patterns of change or possible relationshipsAnalyze in detail a series of events described in a text, determine whether earlier events caused taket, determine whether earlier events caused taket, determine whether earlier events caused taket, determine whether earlier events caused taket ones or simply preceded them.b. Work with peers to schulate a thoughtful, well- reasoned exchange of ideas.Observations and previous scientists work regarding patterns of change or possible relationshipsCredes 11-12: Cite specific textual evidence to support analysis of primary and secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.Determine the central ideas or information of a primary or challenge ideas and conclusions.C. Propel conversations by posing and respond toughtful, verify, or challenge ideas and conclusions.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.Creat and Scientific texture events and texture events and there in event and termine whether earling of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies.Creat and there in event with event and tope cause of the evidence.Craft and Structure: Grades 9-10: Determine the meaning of wo	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
history/social studies. collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on grades 11–12	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	Science and Technical SubjectsKey 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 o 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:
				collaborative discussions (one-on- one, in groups, and





Teacher Guide

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

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 an expressing their own clearly and persuasively. a. Come to discussions prepared, having rea 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 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; 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.



Craft and Structure:		use of evide	nce and rhetoric, identifying any fallacious
Grades 9-10:		reasoning o	r exaggerated or distorted evidence.
Determine the meaning o	f words and	, i i i i i i i i i i i i i i i i i i i	
phrases as they are used		Grades 11-	12:
vocabulary describing pol		Initiate and	participate effectively in a range of
economic aspects of histo			e discussions (one-on- one, in groups, and
	,		with diverse partners on grades 11-12
Grades 11-12:		,	, and issues, building on others' ideas and
Determine the meaning o	f words and		their own clearly and persuasively.
phrases as they are used			ome to discussions prepared, having read
analyzing how an author			nd researched material under study;
the meaning of a key tern			plicitly draw on that preparation by
a text (e.g., how Madison			ferring to evidence from texts and other
Federalist No. 10).			search on the topic or issue to stimulate a
rederaist No. 10).			oughtful, well-reasoned exchange of
			5 ,
Integration of Knowledg	je and Ideas:		eas.
Grades 9-10:			fork with peers to promote civil,
Integrate quantitative or to	· · · · · · · · · · · · · · · · · · ·		emocratic discussions and decision-
(e.g., charts, research da	ta) with qualitative		aking, set clear goals and deadlines, and
analysis in print or digital	text.		stablish individual roles as needed.
			ropel conversations by posing and
Compare and contrast tre	atments of the		sponding to questions that probe
same topic in several prin	nary and secondary		asoning and evidence; ensure a hearing
sources.			r a full range of positions on a topic or
			sue; clarify, verify, or challenge ideas and
Grades 11-12:			onclusions; and promote divergent and
Integrate and evaluate m	ultiple sources of		eative perspectives.
information presented in o	diverse formats and	d. R	espond thoughtfully to diverse
media (e.g., quantitative o	data, video,		erspectives; synthesize comments, claims
multimedia) in order to ad		ar	nd evidence made on all sides of an issue
solve a problem.		re	solve contradictions when possible; and
		de	etermine what additional information or
Synthesize information fro	om a range of	re	search is required to deepen the
sources (e.g., texts, expe	•	in	vestigation or complete the task.
simulations) into a cohere			
a process, phenomenon,	e e e e e e e e e e e e e e e e e e e	Evaluate a s	speaker's point of view, reasoning, and
resolving conflicting inform	• •	use of evide	nce and rhetoric, assessing the stance,
possible.			nks among ideas, word choice, points of
p0001010.			ind tone used.



	Common	Core	State	Standards
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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
	Key Ideas and Details:	Production and Distribution of Writing:	Comprehension and Collaboration:
LO1c:	Grades 9-10:	Grades 9-10:	Grades 9-10:
to construct an	Cite specific textual evidence to support analysis	Produce clear and coherent writing in which the	Initiate and participate effectively in a range of
explanation of the	of primary and secondary sources, attending to	development, organization, and style are	collaborative discussions (one-on-one, in groups
possible geologic	such features as the date and origin of the	appropriate to task, purpose, and audience.	and teacher-led) with diverse partners on grades
sequence in a	information.		9-10 topics, texts, and issues, building on other
		Grades 11-12:	ideas and expressing their own clearly and
THEMIS image	Determine the central ideas or information of a	Produce clear and coherent writing in which the	persuasively.
citing evidence from	primary or secondary source; provide an accurate	development, organization, and style are	a. Come to discussions prepared, havin
resources and class	summary of how key events or ideas develop	appropriate to task, purpose, and audience.	read and researched material under
discourse with	over the course of the text.		study; explicitly draw on that
emphasis on the		Research to Build and Present Knowledge:	preparation by referring to evidence
patterns and	Analyze in detail a series of events described in a	Grades 9-10:	from texts and other research on the
relationships found	text; determine whether earlier events caused	Gather relevant information from multiple	topic or issue to stimulate a thoughtfu
between features	later ones or simply preceded them.	authoritative print and digital sources, using	well-reasoned exchange of ideas.
between leatures		advanced searches effectively; assess the	b. Work with peers to set rules for
	Grades 11-12:	usefulness of each source in answering the	collegial discussions and decision-
	Cite specific textual evidence to support analysis	research question; integrate information into the	making (e.g., informal consensus,
	of primary and secondary sources, connecting	text selectively to maintain the flow of ideas,	taking votes on key issues,
	insights gained from specific details to an	avoiding plagiarism and following a standard	presentation of alternate views), clea
	understanding of the text as a whole.	format for citation.	goals and deadlines, and individual
	Determine the central ideas or information of a	Drow ovidence from informational toute to support	roles as needed.
		Draw evidence from informational texts to support	c. Propel conversations by posing and
	primary or secondary source; provide an accurate summary that makes clear the relationships	analysis, reflection, and research.	responding to questions that relate th current discussion to broader themes
	among the key details and ideas.	Grades 11-12:	or larger ideas; actively incorporate
	among the key details and ideas.	Gather relevant information from multiple	others into the discussion; and clarify
	Evaluate various explanations for actions or	authoritative print and digital sources, using	verify, or challenge ideas and
	events and determine which explanation best	advanced searches effectively; assess the	conclusions.
	accords with textual evidence, acknowledging	strengths and limitations of each source in terms	d. Respond thoughtfully to diverse
	where the text leaves matters uncertain.	of the specific task, purpose, and audience;	perspectives, summarize points of
		integrate information into the text selectively to	agreement and disagreement, and,
	Craft and Structure:	maintain the flow of ideas, avoiding plagiarism	when warranted, qualify or justify the
	Grades 9-10:	and overreliance on any one source and following	own views and understanding and
	Determine the meaning of words and phrases as	a standard format for citation.	make new connections in light of the
	they are used in a text, including vocabulary		evidence and reasoning presented.
	describing political, social, or economic aspects	Draw evidence from informational texts to support	endence and reaconing prosoniou.
	of history/social studies.	analysis, reflection, and research.	Evaluate a speaker's point of view, reasoning,
			and use of evidence and rhetoric, identifying an
	Grades 11-12:		fallacious reasoning or exaggerated or distorted
	Determine the meaning of words and phrases as		evidence.

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



Teacher Guide

(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 used the other including usershiper. 		 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:
	they are used in a text, including vocabulary		Initiate and participate effectively in a range of collaborative

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

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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).	
dennes laction in rederanst 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 courses	
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.	

NASA

Teacher Guide

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

21 st Century Skills		
Learning Outcomes Students will demonstrate the measurable abilities	21 st Century Skill	Grade 12 Benchmark
LO1a: to identify, analyze, and interpret geologic features at different scales in a THEMIS	Collaboration	Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.
image using scientific reasoning and the laws of nature	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	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.
collaboratively construct the geologic history of a variety of features at differing scales of a small portion of Mars	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	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.
the possible geologic sequence in a THEMIS image citing evidence from resources and class discourse with emphasis	Collaboration	Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.
on the patterns and relationships found between features	Flexibility and Adaptability	Students are able to revise their own scientific ideas and hypotheses based on new evidence or information.

Teacher Guide

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

21 st Century Skills			
Learning Outcomes Students will demonstrate the measurable abilities	21 st Century Skill	Grade 12 Benchmark	
LO2a:	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.	
to make a claim, supported by obtained evidence and use sound reasoning of systemic	Collaboration	Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.	
patterns in geologic observations of Mars	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.	





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Teacher Guide

(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 (NC

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.

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	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.



Teacher Guide

(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

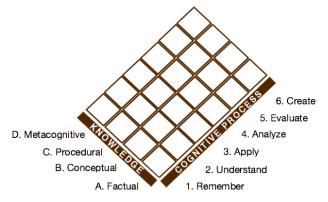
	Expert	Proficient	Intermediate	Beginner
Effectiveness collaboration with team members and class.	Extremely interested in collaborating in the group. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure everyone 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.



Teacher Guide

(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.



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

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Teacher Guide

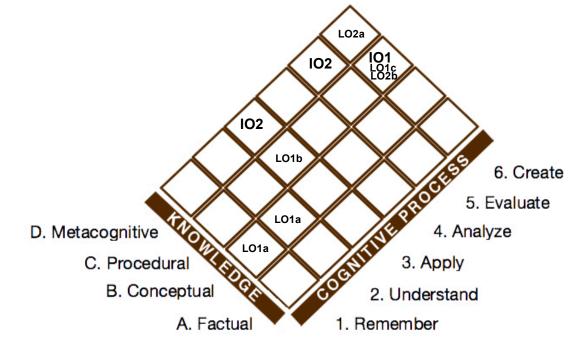
(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

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