Marsbound! Mission to the Red Planet

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

WHAT STUDENTS DO: Design a Mission to Mars.

Curious about how engineers design a Mars mission? In this fun, interactive card simulation, students experience the fundamentals of the engineering design process, with a hands-on, critical-thinking, authentic approach. Using collaboration and problem-solving skills, they develop a mission that meets constraints (budget, mass, power) and criteria (significant science return). This activity can introduce many activities in technology education, including robotics and rocketry.

NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES
HOW DO ENGINEERS SOLVE PROBLEMS? *NGSS Core Question: ETS1: Engineering Design*	*Students will be able to*
What Is a Design for? What are the criteria and constraints of a successful solution? *NGSS ETS1.A: Defining & Delimiting an Engineering Problem* **What Is the Process for Developing Potential Design Solutions?** *NGSS ETS1.B: Developing Possible Solutions* **How can the various proposed design solutions be compared and improved?** *NGSS ETS1.C: Optimizing the Design Solution*	**IO1:** **Create an engineering model of a mission limited by criteria and constraints and designing to achieve the task of using the "looking for signs of life" strategy on Mars.**

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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. Construction of rubrics also draws upon Lanz's (2004) guidance, designed to measure science achievement.

How Students Learn: Science in the Classroom (Donovan & Bransford, 2005) advocates the use of a research-based instructional model for improving students' grasp of central science concepts. Based on conceptual-change theory in science education, the 5E Instructional Model (BSCS, 2006) includes five steps for teaching and learning: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage stage is used like a traditional warm-up to pique student curiosity, interest, and other motivation-related behaviors and to assess students' prior knowledge. The Explore step allows students to deepen their understanding and challenges existing preconceptions and misconceptions, offering alternative explanations that help them form new schemata. In Explain, students communicate what they have learned, illustrating initial conceptual change. The Elaborate phase gives students the opportunity to apply their newfound knowledge to novel situations and supports the reinforcement of new schemata or its transfer. Finally, the Evaluate stage serves as a time for students' own formative assessment, as well as for educators' diagnosis of areas of confusion and differentiation of further instruction. This five-part sequence is the organizing tool for the Imagine Mars instructional series. The 5E stages can be cyclical and iterative.

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2.0 Instructional Objectives, Learning Outcomes, & Standards

Instructional objectives and learning outcomes are aligned with

- National Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)'s, *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and* Technical Subjects
- Partnership for 21st Century Skills, *A Framework for 21st Century Learning*

The following chart provides details on alignment among the core and component NGSS questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the NGSS Framework and NGSS.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO)**.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics** (see Teacher Guide at the end of this lesson).

Quick View of Standards Alignment:

The Teacher Guide at the end of this lesson provides full details of standards alignment, rubrics, and the way in which instructional objectives, learning outcomes, 5E activity procedures, and assessments were derived through, and align with, Anderson and Krathwohl's (2001) taxonomy of knowledge and cognitive process types. For convenience, a quick view follows:

HOW DO ENGINEERS SOLVE PROBLEMS?

NGSS Core Idea: A: ETS1: Engineering Design

What is Design for? What are the criteria and constraints of a successful solution?

NGSS ETS1.A: Defining and Delimiting an Engineering Solution

What is the Process for Developing Potential Design Solutions?

NGSS ETS1.B: Developing Possible Solutions

How can the various proposed design solutions be compared and improved?

NGSS ETS1.C: Optimizing the Design Solution

Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: **Create an engineering model of a mission limited by criteria and constraints and designing to achieve the task of using the "looking for signs of life" strategy on Mars.**	**LO1a. to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution** **LO1b. to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a complex design structure** **LO1c: to identify and explain the specific components of the engineering design cycle for the designed model** **LO1d: to identify and explain the complex relationship between science and engineering design**	**DISCIPLINARY CORE IDEA:** **EST1.A: Defining and Delimiting Engineering Problems** **EST1.B: Developing Possible Solutions** **EST1.C: Optimizing the Design Solution** **PRACTICES:** **1. Asking Questions and Defining Problems** **2. Developing and Using Models** **3. Planning and Carrying Out Investigations** **4. Analyzing and Interpreting Data** **5. Constructing Explanations and Designing Solutions** **6. Engaging in Argument from Evidence** **7. Obtaining, Evaluating, and Communicating Information** **CROSSCUTTING CONCEPTS:** **1. Patterns** **2. Scale, Proportion, and Quantity** **3. Systems and System Models** **4. Structure and Function** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** **Science is a Human Endeavor**

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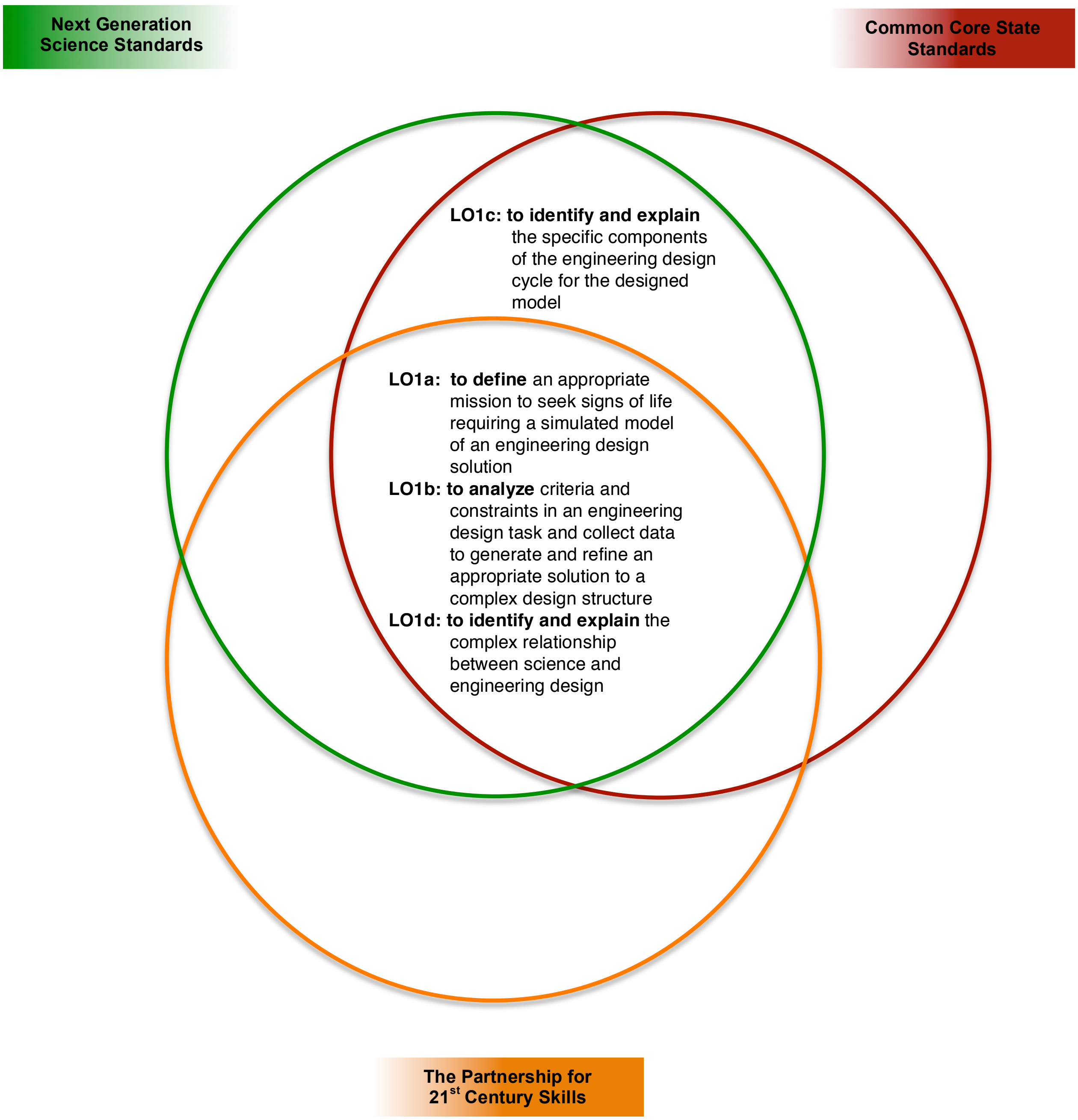
3.0 Learning Outcomes, NGSS, Common Core, & 21st Century Skills Connections

The connections diagram is used to organize the learning outcomes addressed in the lesson to establish where each will meet the Next Generation Science Standards, ELA Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents.



4.0 Evaluation/Assessment

Rubric*:* A rubric has been provided to assess student understanding of the simulation and to assess metacognition. A copy has been provided in the Student Guide for students to reference prior to the simulation. This rubric will allow them to understand the expectations set before them.

5.0 References

Achieve, Inc. (2013). *Next generation science standards*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.

Anderson, L.W., & Krathwohl (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* New York: Longman.

Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications.* Colorado Springs: BSCS.

Donovan, S. & Bransford, J. D. (2005). *How Students Learn: History, Mathematics, and Science in the Classroom.* Washington, DC: The National Academies Press.

Miller, Linn, & Gronlund. (2009). *Measurement and assessment in teaching*. Upper Saddle River, NJ: Pearson.

National Academies Press. (1996, January 1). *National science education standards*. Retrieved February 7, 2011 from http://www.nap.edu/catalog.php?record_id=4962

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washington, DC: Authors.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

The Partnership for 21st Century Skills (2011). *A framework for 21st century learning.* Retrieved March 15, 2012 from http://www.p21.org

(L) Teacher Resource. Marsbound! NGSS Alignment (1 of 3)

You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

Related Standard(s)
This lesson supports the preparation of students toward achieving Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below:
(MS-ETS1-1), (MS-ETS1-2), (MS-ETS1-3), (MS-ETS1-4);

Next Generation Science Standards Alignment (NGSS)

Instructional Objective	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO1: **Create an engineering model of a mission limited by criteria and constraints and designing to achieve the task of using the "looking for signs of life" strategy on Mars.**	**Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	**ETS1.A: Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions:** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)	**Systems and system models**: Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.

		The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	

(L) Teacher Resource. Marsbound! NGSS Alignment (2 of 3)

Next Generation Science Standards Alignment (NGSS)

Learning Outcomes	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: **to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution**	**Asking Questions and Defining Problems:** Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A: Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)	**Scale, Proportion, and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
LO1b: **to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a complex design structure**	**Asking Questions and Defining Problems:** Ask questions to clarify and/or refine a model, an explanation, or an engineering problem. Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. **Planning and Carrying Out Investigations:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Analyzing and Interpreting Data:** Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Constructing Explanations and Designing**	**ETS1.A: Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions:** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign	**Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

	Solutions: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	
LO1c: to identify and explain the specific components of the engineering design cycle for the designed model	**Engaging in Argument from Evidence:** Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	**ETS1.C: Optimizing the Design Solution:** The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Systems and System Models:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
LO1d: to identify and explain the complex relationship between science and engineering design	**Constructing Explanations and Designing Solutions:** Construct an explanation using models or representations. Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	**Interdependence of Science, Engineering, and Technology:** Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. Science and technology drive each other forward.	**Patterns:** Patterns can be used to identify cause and effect relationships. **Systems and System Models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

(L) Teacher Resource. Marsbound! NGSS Individual Activity Alignment (3 of 3)

Next Generation Science Standards Activity Alignments (NGSS)

Activity	Phases of 5E Instructional Model	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
(C & D) Activity 1 Fact Sheet and Science Objective Worksheets	**Engage Explain**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	**ETS1.A: Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)	**Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
(E) Mission Goals	**Explore Explain**	**Asking Questions and Defining Problems:** Ask questions to clarify and/or refine a model, an explanation, or an engineering problem. Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A: Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)	**Scale, Proportion, and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Systems and System Models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. Models are limited in that they only represent certain aspects of the system under study.
(F & G) Building your Spacecraft Fact Sheet and Spacecraft Design Log	**Explore Explain**	**Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	**ETS1.C: Optimizing the Design Solution:** The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they

		Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Analyzing and Interpreting Data:** Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Engaging in Argument from Evidence:** Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.		function.
(H) Engineering Constraints	**Explain**	**Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. **Analyzing and Interpreting Data:** Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Constructing Explanations and Designing Solutions:** Apply scientific ideas,	**ETS1.B: Developing Possible Solutions:** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)	**Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

		principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. **Engaging in Argument from Evidence:** Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.		
(I) Engineering Design Cycle	**Evaluate**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	**ETS1.B: Developing Possible Solutions:** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

(J) Post-Ideas	**Evaluate**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. **Engaging in Argument from Evidence:** Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.	**ETS1.B: Developing Possible Solutions:** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Patterns:** Patterns can be used to identify cause and effect relationships. **Science is a Human Endeavor:** Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas. Advances in technology influence the progress of science and science has influenced advances in technology.

(M) Teacher Resource. Marsbound! CCSS Alignment (1 of 3)

Common Core State Standards

Instructional Objective	Reading Standards for Literacy in Science and Technical Subjects (6-8)	Writing Standards for Literacy in Science and Technical Subjects (6-8)	Speaking and Listening Standards (6-8)
IO1: **Create an engineering model of a mission limited by criteria and constraints and designing to achieve the task of using the "looking for signs of life" strategy on Mars.**	**Key Ideas and Details:** **Grade 6-8:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **Craft and Structure:** **Grade 6-8:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. **Integration of Knowledge and Ideas:** **Grade 6-8:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	**Text Types and Purposes:** **Grade 6-8:** Write arguments focused on discipline-specific content. • Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. • Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. • Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. • Establish and maintain a formal style. • Provide a concluding statement or section that follows from and supports the argument presented. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. • Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. • Use appropriate and varied transitions to	**Comprehension and Collaboration:** **Grade 6:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. • Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. • Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not. **Grade 7:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or

		• create cohesion and clarify the relationships among ideas and concepts. • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Establish and maintain a formal style and objective tone. • Provide a concluding statement or section that follows from and supports the information or explanation presented. **Research to Build and Present Knowledge:** **Grades 6-8:** Draw evidence from informational texts to support analysis reflection, and research	• researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. • Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. • Acknowledge new information expressed by others and, when warranted, modify their own views. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence. **Grade 8:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. • Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. • Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.

(M) Teacher Resource. Marsbound! CCSS Alignment (2 of 3)

Common Core State Standards			
Learning Outcome	**Reading Standards for Literacy in Science and Technical Subjects (6-8)**	**Writing Standards for Literacy in Science and Technical Subjects (6-8)**	**Speaking and Listening Standards (6-8)**
LO1a: **to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution** **LO1b:** **to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a complex design structure**	**Key Ideas and Details:** **Grade 6-8:** Cite specific textual evidence to support analysis of science and technical texts. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **Craft and Structure:** **Grade 6-8:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. **Integration of Knowledge and Ideas:** **Grade 6-8:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).		**Comprehension and Collaboration:** **Grade 6:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. • Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. • Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. • Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not. **Grade 7:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or researched material under study; explicitly draw on

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

(M) Teacher Resource. Marsbound! CCSS Alignment (3 of 3)

Common Core State Standards

Learning Outcome	Reading Standards for Literacy in Science and Technical Subjects (6-8)	Writing Standards for Literacy in Science and Technical Subjects (6-8)	Speaking and Listening Standards (6-8)
LO1c: to identify and explain the specific components of the engineering design cycle for the designed model **LO1d:** to identify and explain the complex relationship between science and engineering design		**Text Types and Purposes:** **Grade 6-8:** Write arguments focused on discipline-specific content. • Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. • Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. • Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. • Establish and maintain a formal style. • Provide a concluding statement or section that follows from and supports the argument presented. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. • Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. • Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Establish and maintain a formal style and objective tone. • Provide a concluding statement or section that follows from and supports the information or explanation presented. **Research to Build and Present Knowledge:** **Grades 6-8:** Draw evidence from informational texts to support analysis reflection, and research	

(M) Teacher Resource. Marsbound! 21st Century Skills Alignment (1 of 1)

21st Century Skills

Learning Outcomes	21st Century Skill	Grade 8 Benchmark
LO1a: to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution	**Collaboration**	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Media Literacy	Students are able to identify and critique arguments in which the claims are not consistent with the evidence given.
	Social and Cross-Cultural Skills	Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
LO1b: to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a complex design structure	**Collaboration**	Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Media Literacy	Students are able to identify and critique arguments in which the claims are not consistent with the evidence given.
	Social and Cross-Cultural Skills	Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
LO1c: to identify and explain the specific components of the engineering design cycle for the designed model		

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LO1d: to **identify and explain** the **complex relationship between science and engineering design**	**Creativity and Innovation**	Students are able to describe how science and engineering involve creative processes that include generating and testing ideas, making observations, and formulating explanations; and can apply these processes in their own investigations.

(O) Teacher Resource. Marsbound! NGSS Rubric (1 of 3)

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

Next Generation Science Standards Alignment (NGSS)

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution	Mars Exploration Program Goals are chosen because the student is able to identify and explain the strong connection between water and the need to answer the science question to learn more about those water processes. Goals take into account the complexity of identifying a mission strategy. Modifies design significantly using these pre-established science goals during the simulation.	Mars Exploration Program Goals are chosen because the student is able to explain the water processes involved and/or how they work. Goals take into account the complexity of identifying a mission strategy. Moderately modifies design using these pre-established science goals during the simulation	Mars Exploration Program Goals are chosen because student is able to identify that there is a connection to water processes, but may not be clear on what the processes are or how they work. Modifies design using these pre-established science goals during the simulation.	Mars Exploration Program Goals are chosen because the student likes or prefers them. Responses are often limited to 1 or 2 words.
LO1b: to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a complex design structure	Design takes into account complexity of balancing budget, mass, power and science return. Modifies design significantly using pre-established science goals during the simulation.	Design accounts for complexity of balance between budget, mass, power and science return. Modifies the design during the simulation.	Design takes into account the balance between budget, mass, and power and therefore modifies the design during the simulation.	Design tends to focus only on Spacecraft components that are of interest to the builder, and is over budget, mass, and or power.
LO1c: to identify and explain the specific components of the engineering design cycle for the designed model	Justifications are based on experiences in the simulation and are relevant to engineering constraints within the design cycle. Demonstrates complexity of these constraints and iterations.	Justifications are based on experiences in the simulation and selects examples that partially describe the complexity in engineering constraints and the iterations.	Justifications are based on experiences in the simulation. Student identifies examples from the simulation.	Justifications are based on misconceptions or previous understanding / beliefs. Uses personal preferences for justification.

LO1d: to identify and explain the complex relationship between science and engineering design	Post-survey responses demonstrate the student has connected to the complexity of mission planning and recognizes their new understanding of mission planning.	Post-survey demonstrates the student has connected to the complexity of mission planning using a variety of examples and explanations.	Post-Survey responses indicate an understanding of the connection between engineering constraints and a good mission.	Post-Survey responses tend to focus on one engineering constraints or are very similar to Pre-Survey responses.

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(P) Teacher Resource. Marsbound! CCSS Rubric (2 of 3)

Common Core State Standards

	Expert	Proficient	Intermediate	Beginner
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.
Effective Demonstration of 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.
Text Types and Purpose	Introduces topic clearly, provides a general observation and focus, and groups related information logically; Develops the topic with facts, definitions, concrete details, or other examples related to the topic; Links ideas using words, phrases, and clauses; Use domain-specific vocabulary to explain the topic; Provides a concluding statement related to the explanation.	Introduces topic clearly, provides a general observation, or groups related information logically; Develops the topic with concrete details, or other examples related to the topic; Links ideas using words or phrases; Uses domain-specific vocabulary to explain the topic; Provides a concluding statement related to the explanation.	Introduces topic, provides a general observation; Develops the topic with details, or other examples related to the topic; Links ideas using words or phrases; Uses domain-specific vocabulary to explain the topic; May or may not provide a concluding statement.	Introduces topic; Develops the topic with details, or other examples, potentially unrelated; Uses specific vocabulary to explain the topic; May or may not provide a concluding statement.
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 vocabulary through mission planning.	Develops strong, vocabulary through mission planning.	Develops vocabulary through mission planning.	Vocabulary is rudimentary and based on prior understanding.

Integration of Knowledge	Successfully combines information from lesson with resources to develop a deep understanding of a the topic.	Successfully combines information from lesson with resources to develop an understanding of a topic.	Combines information from lesson with resources to develop a summary of a topic.	References text from resources to develop a summary of a topic.

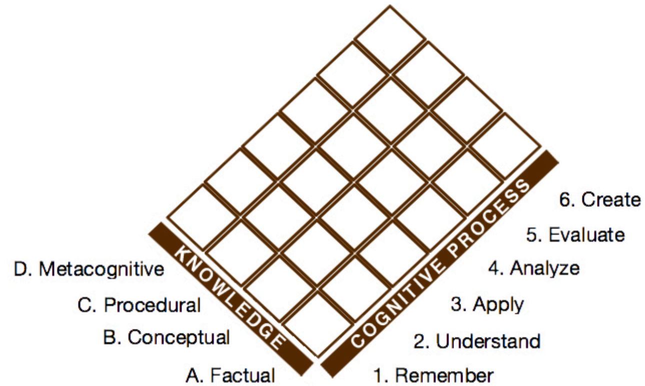
(Q) Teacher Resource. Marsbound! 21st Century Skills Rubric (3 of 3)

Partnership for 21st Century Skills

	Expert	Proficient	Intermediate	Beginner
Effectiveness of social and cross-cultural collaboration with team members and class.	Extremely interested in collaborating in the simulation. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure everyone has a contribution.	Extremely interested in collaborating in the simulation. Actively provides suggestions and occasionally listens to suggestions from others. Refines suggestions from others.	Interested in collaborating in the simulation. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the simulation.
Effectiveness of Media Literacy	Actively listens to suggestions and ideas from others while asking clarifying questions to ensure claims are consistent with the evidence provided.	Listens to suggestions and ideas from others while asking clarifying questions to ensure claims are consistent with the evidence provided.	Listens to suggestions and ideas from others and asking clarifying questions while following their direction.	Listens to the suggestions provided by others and follows their direction.
Effectiveness of Creativity, Innovation and Flexibility	Model is an excellent representation of a wide variety of generating and testing of ideas to achieve equilibrium while acquiring high science return.	Model is an excellent representation of a wide variety of generating and testing of ideas to achieve equilibrium while acquiring moderate science return.	Model is a representation of a variety of generating and testing of ideas to achieve equilibrium while acquiring moderate science return.	Model is a representation of generating and testing of ideas to achieve equilibrium while acquiring at least one science return.

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

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



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

(R) 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.

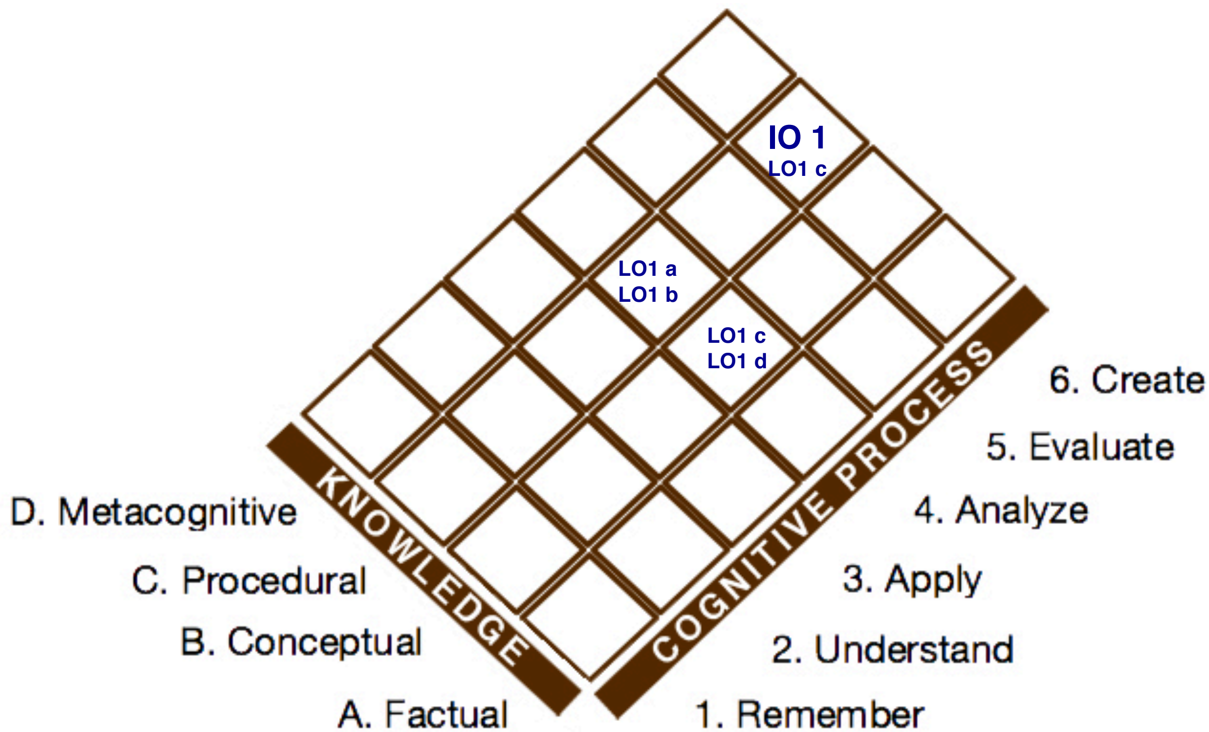
IO1: Create an engineering model of an astrobiology mission limited by criteria and constraints and designed to achieve the task of looking for past or present life in the Solar System. (6.1; Cb)

LO1a. to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution (4.2; Cb)

LO1b. to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a complex design structure (4.2; Cb)

LO1c. to identify and explain the specific components of the engineering design cycle for the designed model (4.3; Ba)

LO1d. to identify and explain the complex relationship between science and engineering design (4.3; Ba)



(R) 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: Create an engineering model

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

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

LO1a: to define an appropriate mission

4.2: to structure
Cb: Knowledge of subject-specific techniques and methods

LO1b: to analyze criteria and constraints in an engineering design

4.2: to find coherence
Cb: Knowledge of subject-specific techniques and methods

LO1c: to identify and explain the specific components of the engineering design cycle

4.3: to deconstruct
Ba: Knowledge of classifications and categories

LO1d: to identify and explain the complex relationship between science and engineering design

4.3: to deconstruct
Ba: Knowledge of classifications and categories