Marsbound! Mission to the Red Planet

3rd – 5th Grade 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

HOW DO ENGINEERS SOLVE PROBLEMS?

NGSS Core Question: ETS1: Engineering Design

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

INSTRUCTIONAL OBJECTIVES

Students will be able to

IO1: **Generate and compare an analogous model of an engineering mission, limited by specified criteria and constraints and choosing appropriate interacting instruments in 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:

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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: **Generate and compare an analogous model of an engineering mission, limited by specified criteria and constraints and choosing appropriate interacting instruments in 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 system model** **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** **Interdependence of Science, Engineering, and Technology** **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. Cause and Effect** **2. Scale, Proportion, and Quantity** **3. Systems and System Models** **4. Structure and Function** **Science is a Human Endeavor**

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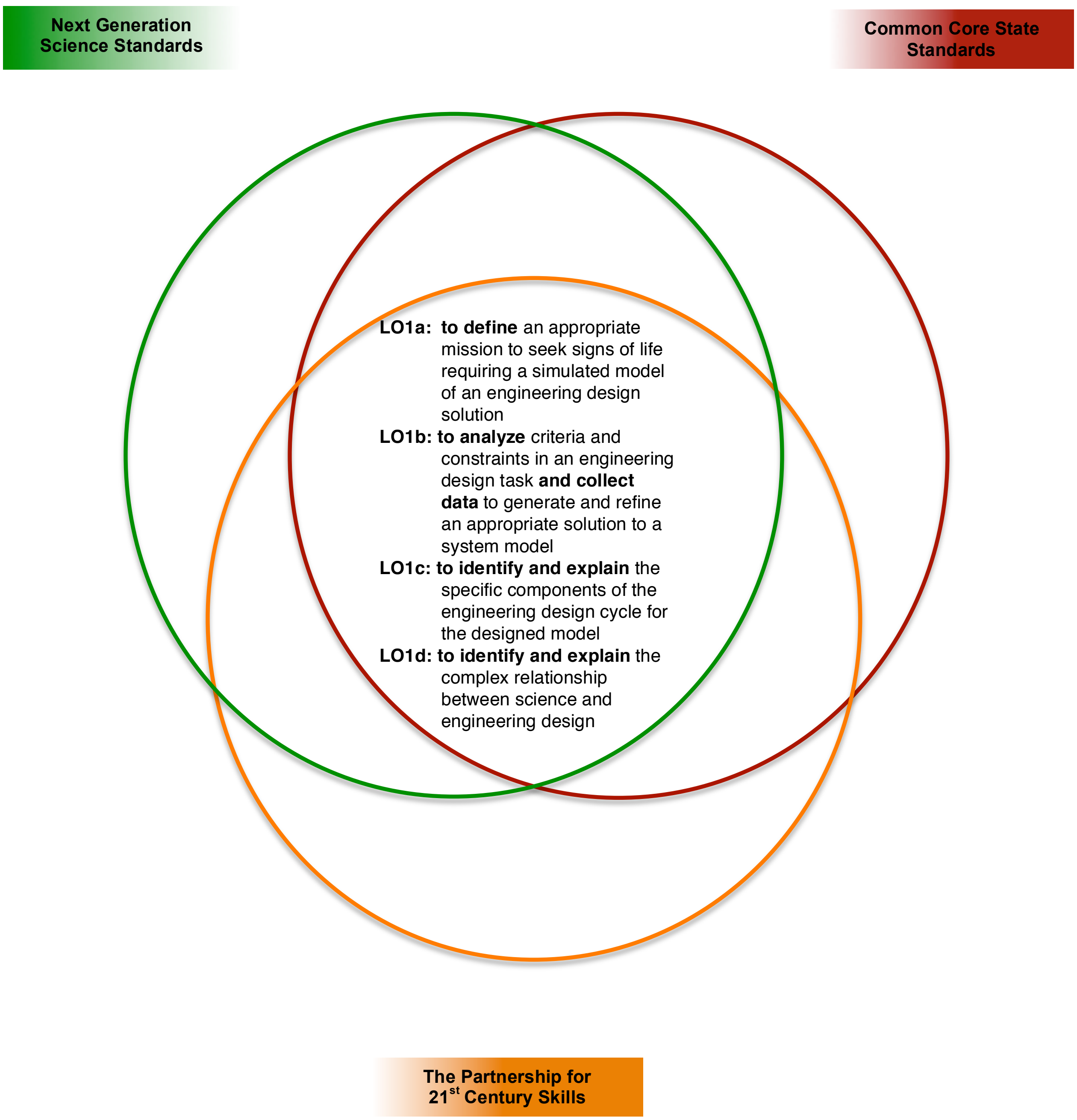
3.0 Learning Outcomes, NGSS, Common Core, & 21st Century Skills Connections

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.



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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

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(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:

(3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)

Next Generation Science Standards Alignment (NGSS)

Instructional Objective	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO1: **Generate and compare an analogous model of an engineering mission, limited by specified criteria and constraints and choosing appropriate interacting instruments in the "looking for signs of life" strategy on Mars.**	**Developing and Using Models:** Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.	**ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) **ETS1.B: Developing Possible Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	**Systems and System Models**: A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.

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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 simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. **Developing and Using Models:** Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.	**ETS1.A: Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)	**Systems and System Models**: A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.
LO1b: **to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a system model**	**Developing and Using Models:** Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. **Planning and Carrying Out Investigations:** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. Test two different models of the same proposed object, tool, or process to determine which	**ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) **ETS1.B: Developing Possible Solutions** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)	**Cause and Effect:** Cause and effect relationships are routinely identified, tested, and used to explain change. **Structure and Function:** Substructures have shapes and parts that serve functions. **Systems and System Models**: A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.

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	better meets criteria for success. **Analyzing and Interpreting Data:** Analyze data to refine a problem statement or the design of a proposed object, tool, or process. Use data to evaluate and refine design solutions. **Constructing Explanations and Designing Solutions:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**ETS1.C: Optimizing the Design Solution** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	
LO1c: **to identify and explain the specific components of the engineering design cycle for the designed model**	**Analyzing and Interpreting Data:** Use data to evaluate and refine design solutions. **Constructing Explanations and Designing Solutions:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. **Engaging in Argument from Evidence:** Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.	**ETS1.B: Developing Possible Solutions:** At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	**Systems and System Models:** A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions. **Scale, Proportion and Quantity:** Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

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LO1d: **to identify and explain the complex relationship between science and engineering design**	**Constructing Explanations and Designing Solutions:** Construct an explanation of observed relationships. Identify the evidence that supports particular points in an explanation. Apply scientific ideas to solve design problems. **Engaging in Argument from Evidence:** Construct and/or support an argument with evidence, data, and/or a model.	**Interdependence of Science, Engineering, and Technology:** Science and technology support each other. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.	**Science is a Human Endeavor:** Most scientists and engineers work in teams.

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(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 to solve design problems. **Obtaining, Evaluating, and Communicating Information:** Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.	**ETS1.A: Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)	**Science is a Human Endeavor:** Most scientists and engineers work in teams.
(E) Mission Goals	**Explore** **Explain**	**Asking Questions and Defining Problems:** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	**ETS1.A: Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)	**Scale, Proportion and Quantity:** Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods.
(F & G) Building your Spacecraft Fact Sheet and Spacecraft Design Log	**Explore** **Explain**	**Developing and Using Models:** Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. **Planning and Carrying Out Investigations:** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.	**ETS1.C: Optimizing the Design Solution:** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	**Systems and System Models**: A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions. **Structure and Function:** Substructures have shapes and parts

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		Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.		that serve functions.
(H) Engineering Constraints	**Explain**	**Constructing Explanations and Designing Solutions:** Construct an explanation of observed relationships. Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. Identify the evidence that supports particular points in an explanation.	**ETS1.B: Developing Possible Solutions:** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)	**Cause and Effect:** Cause and effect relationships are routinely identified, tested, and used to explain change. **Systems and System Models**: A system can be described in terms of its components and their interactions.
(I) Engineering Design Cycle	**Evaluate**	**Constructing Explanations and Designing Solutions:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**ETS1.B: Developing Possible Solutions:** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	**Cause and Effect:** Cause and effect relationships are routinely identified, tested, and used to explain change. **Systems and System Models**: A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions. **Structure and Function:** Substructures have shapes and parts that serve functions.

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(J) Post-Ideas	**Evaluate**	**Constructing Explanations and Designing Solutions:** Construct an explanation of observed relationships. Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. Identify the evidence that supports particular points in an explanation.	**ETS1.B: Developing Possible Solutions:** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	**Science is a Human Endeavor:** Most scientists and engineers work in teams.

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

Common Core State Standards			
Instructional Objective	**Reading Standards (3-5)**	**Writing Standards (3-5)**	**Speaking and Listening Standards (3-5)**
IO1: **Generate and compare an analogous model of an engineering mission, limited by specified criteria and constraints and choosing appropriate interacting instruments in the "looking for signs of life" strategy on Mars.**		**Grade 3:** **Text Types and Purposes:** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Introduce a topic and group related information together; include illustrations when useful to aiding comprehension. • Develop the topic with facts, definitions, and details. • Use linking words and phrases (e.g., also, another, and, more, but) to connect ideas within categories of information. • Provide a concluding statement or section. **Production and Distribution of Writing:** With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose. (Grade-specific expectations for writing types are defined in standards 1–3 above.) **Research to Build and Present Knowledge:** Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. **Grade 4:** **Text Types and Purposes:** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.	**Grade 3:** **Comprehension and Collaboration:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. • Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). • Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others. • Explain their own ideas and understanding in light of the discussion. **Presentation of Knowledge and Ideas:** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification. (See grade 3 Language standards 1 and 3 on pages 28 and 29 for specific expectations.)

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		• Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic. • Link ideas within categories of information using words and phrases (e.g., another, for example, also, because). • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Provide a concluding statement or section related to the information or explanation presented. **Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.) **Research to Build and Present Knowledge:** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **Grade 5:** **Text Types and Purposes:** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension. • Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic. • Link ideas within and across categories of information using words, phrases, and clauses (e.g., in contrast, especially). • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Provide a concluding statement or section	**Grade 4:** **Comprehension and Collaboration:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. • Follow agreed-upon rules for discussions and carry out assigned roles. • Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others. • Review the key ideas expressed and explain their own ideas and understanding in light of the discussion. **Presentation of Knowledge and Ideas:** Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace. Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation. (See grade 4 Language standards 1 on pages 28 and 29 for specific expectations.) **Grade 5:** **Comprehension and Collaboration:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly

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		related to the information or explanation presented. **Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. **Research to Build and Present Knowledge:** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.	draw on that preparation and other information known about the topic to explore ideas under discussion. • Follow agreed-upon rules for discussions and carry out assigned roles. • Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others. • Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions. **Presentation of Knowledge and Ideas:** Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace. Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation. (See grade 5 Language standards 1 and 3 on pages 28 and 29 for specific expectations.)

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

Common Core State Standards

Learning Outcome	Reading Standards (3-5)	Writing Standards (3-5)	Speaking and Listening Standards (3-5)
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 system model**			**Grade 3:** **Comprehension and Collaboration:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. • Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). • Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others. • Explain their own ideas and understanding in light of the discussion. **Presentation of Knowledge and Ideas:** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification. (See grade 3 Language standards 1 and 3 on pages 28 and 29 for specific expectations.) **Grade 4:** **Comprehension and Collaboration:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. • Follow agreed-upon rules for discussions and carry out assigned roles. • Pose and respond to specific questions to clarify or follow up on

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			information, and make comments that contribute to the discussion and link to the remarks of others. • Review the key ideas expressed and explain their own ideas and understanding in light of the discussion. **Presentation of Knowledge and Ideas:** Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace. Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation. (See grade 4 Language standards 1 on pages 28 and 29 for specific expectations.) **Grade 5:** **Comprehension and Collaboration:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly. • Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. • Follow agreed-upon rules for discussions and carry out assigned roles. • Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others. • Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions. **Presentation of Knowledge and Ideas:** Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace. Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation. (See grade 5 Language standards 1 and 3 on pages 28 and 29 for specific expectations.)

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

Common Core State Standards

Learning Outcome	Reading Standards (3-5)	Writing Standards (3-5)	Speaking and Listening Standards (3-5)
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		**Grade 3:** **Text Types and Purposes:** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Introduce a topic and group related information together; include illustrations when useful to aiding comprehension. • Develop the topic with facts, definitions, and details. • Use linking words and phrases (e.g., also, another, and, more, but) to connect ideas within categories of information. • Provide a concluding statement or section. **Production and Distribution of Writing:** With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose. (Grade-specific expectations for writing types are defined in standards 1–3 above.) **Research to Build and Present Knowledge:** Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. **Grade 4:** **Text Types and Purposes:** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension. • Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic. • Link ideas within categories of information using words and phrases (e.g., another, for example, also, because). • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Provide a concluding statement or section related to the information or	

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		explanation presented. **Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.) **Research to Build and Present Knowledge:** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **Grade 5:** **Text Types and Purposes:** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension. • Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic. • Link ideas within and across categories of information using words, phrases, and clauses (e.g., in contrast, especially). • Use precise language and domain-specific vocabulary to inform about or explain the topic. • Provide a concluding statement or section related to the information or explanation presented. **Production and Distribution of Writing:** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. **Research to Build and Present Knowledge:** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.	

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(N) Teacher Resource. Marsbound! 21st Century Skill Alignment (1 of 1)

21st Century Skills

Learning Outcomes	21st Century Skill	Benchmarks
LO1a: to define an appropriate mission to seek signs of life requiring a simulated model of an engineering design solution	**Communication**	**Grade 4 Benchmark:** Students understand that models are simplified representations of real objects and processes, and that models serve as a means to communicate ideas and knowledge about how things work.
	Collaboration	**Grade 4 Benchmark:** Students work collaboratively with others, both in small and large groups, in their science classroom. **Grade 8 Benchmark:** Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Social and Cross-Cultural Skills	**Grade 8 Benchmark:** Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
	Productivity and Accountability	**Grade 4 Benchmark:** Students identify a variety of tools and techniques that scientists use to gather scientific information depending on what it is they want to know and the circumstances under which data will be collected.
LO1b: to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution to a system model	**Collaboration**	**Grade 4 Benchmark:** Students work collaboratively with others, both in small and large groups, in their science classroom. **Grade 8 Benchmark:** Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Social and Cross-Cultural Skills	**Grade 8 Benchmark:** Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
LO1c: to identify and explain the specific	**Creativity and Innovation**	**Grade 4 Benchmark:** Students provide concrete examples of science as a way of thinking that involves both systematic and creative processes that anyone can apply as they ask questions, solve problems, invent things, and develop ideas about the world around them.

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components of the engineering design cycle for the designed model		**Grade 8 Benchmark:** 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.
LO1d: **to identify and explain the complex relationship between science and engineering design**	**Creativity and Innovation**	**Grade 4 Benchmark:** Students provide concrete examples of science as a way of thinking that involves both systematic and creative processes that anyone can apply as they ask questions, solve problems, invent things, and develop ideas about the world around them. **Grade 8 Benchmark:** 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.

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(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 system model	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.

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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, possibly more for the social aspect.
Text Types, Purpose and Distribution	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. Development and organization are appropriate to the task, purpose, and audience.	Introduces topic, provides a general observation, or groups related information; 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. Development and organization are appropriate to the task, purpose, and audience.	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 own vocabulary to explain the topic; May or may not provide a concluding statement. Development and organization is coherent.	Introduces topic; Develops the topic with details, or other examples, potentially out of context; Uses own vocabulary to explain the topic; May or may not provide a concluding statement. Uses bullet points for organization.

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(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 in 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.
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. Achieved a final mission plan.	Model is an excellent representation of a wide variety of generating and testing of ideas to achieve equilibrium while acquiring moderate science return. Achieved a final mission plan.	Model is a representation of a variety of generating and testing of ideas to achieve equilibrium while acquiring moderate science return. May or may not have achieved a final mission plan.	Model is a representation of generating and testing of ideas to achieve equilibrium while acquiring at least one science return. May or may not have achieved a final mission plan.
Effectiveness of Productivity and Accountability	Model demonstrates a wide variety of tools (instruments) appropriate to the type of research to be done in the mission plan.	Model demonstrates tools (instruments) appropriate to the type of research to be done in the mission plan.	Model demonstrates tools (instruments) with the majority of those being appropriate to the type of research to be done in the mission plan.	Model demonstrates tools (instruments) with few, if any, of those being appropriate to the type of research to be done in the mission plan.

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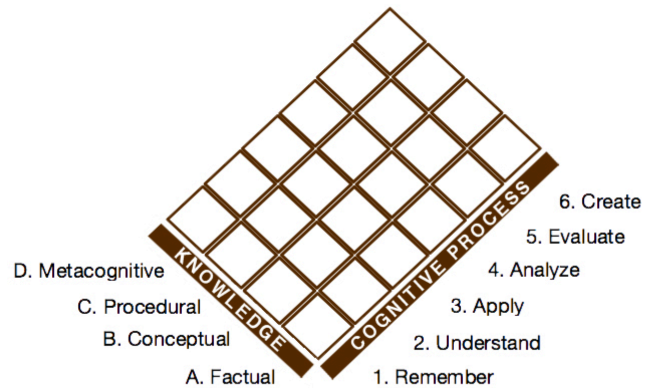
(R) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (1 of 3)

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

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(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.

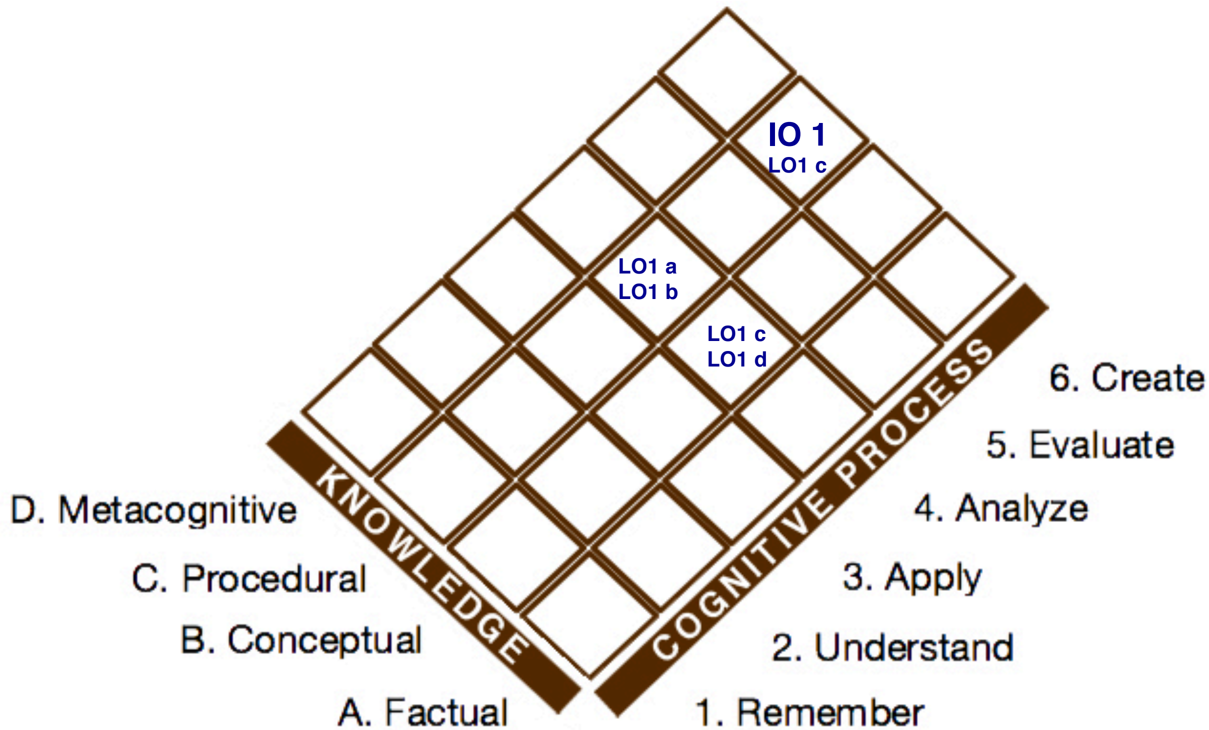
IO1: Generate and compare an analogous model of an engineering mission, limited by specified criteria and constraints and choosing appropriate interacting instruments in the "looking for signs of life" strategy on Mars. (6.1; Cb)

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 system model (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)



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(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: Generate and Compare 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 and collect data

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

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