Strange New Planet

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

WHAT STUDENTS DO: Explore a Model Planet to Discover New Features

Students find out how human curiosity in planetary exploration results in science questions, engineering solutions, and teamwork. This activity demonstrates how planetary features are discovered by the use of remote-sensing techniques. Students will experience the different phases in planetary exploration, including telescope observations, fly by missions, orbiters, landers, rovers…and their own ideas about human exploration. In this collection, this lesson provides one of the building blocks for understanding the relationship among science, engineering, technology, and teamwork, necessary to discovery and innovation.

NRC FRAMEWORK / NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES (IO)
HOW DO ENGINEERS SOLVE PROBLEMS? *NRC Core Question: ETS1: Engineering Design* **What is a design for? What are the criteria and constraints of a successful solution?** *NRC ETS1.A: Defining and Delimiting an Engineering Problem*	*Students will be able to* **IO1: use a physical model to investigate and describe how scientists and engineers understand the limitations presented through certain technologies and use a variety of increasingly complex tools to explore our solar system**

Last edited: March 31, 2016

1.0 About This Activity

The 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 Mars instructional series. The 5E stages can be cyclical and iterative.

2.0 Instructional Objectives, Learning Outcomes, & Standards

Instructional objectives and learning outcomes are aligned with

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

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

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

Important Note: This lesson is color-coded to help teachers identify each of the three dimensions of NGSS. The following identifying colors are used: Practices are blue, Cross-Cutting Concepts are green, and Disciplinary Core Ideas are orange.

This color-coding is consistent with the NGSS Performance Expectations and Foundation Boxes.

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:

Last edited: March 31, 2016

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?

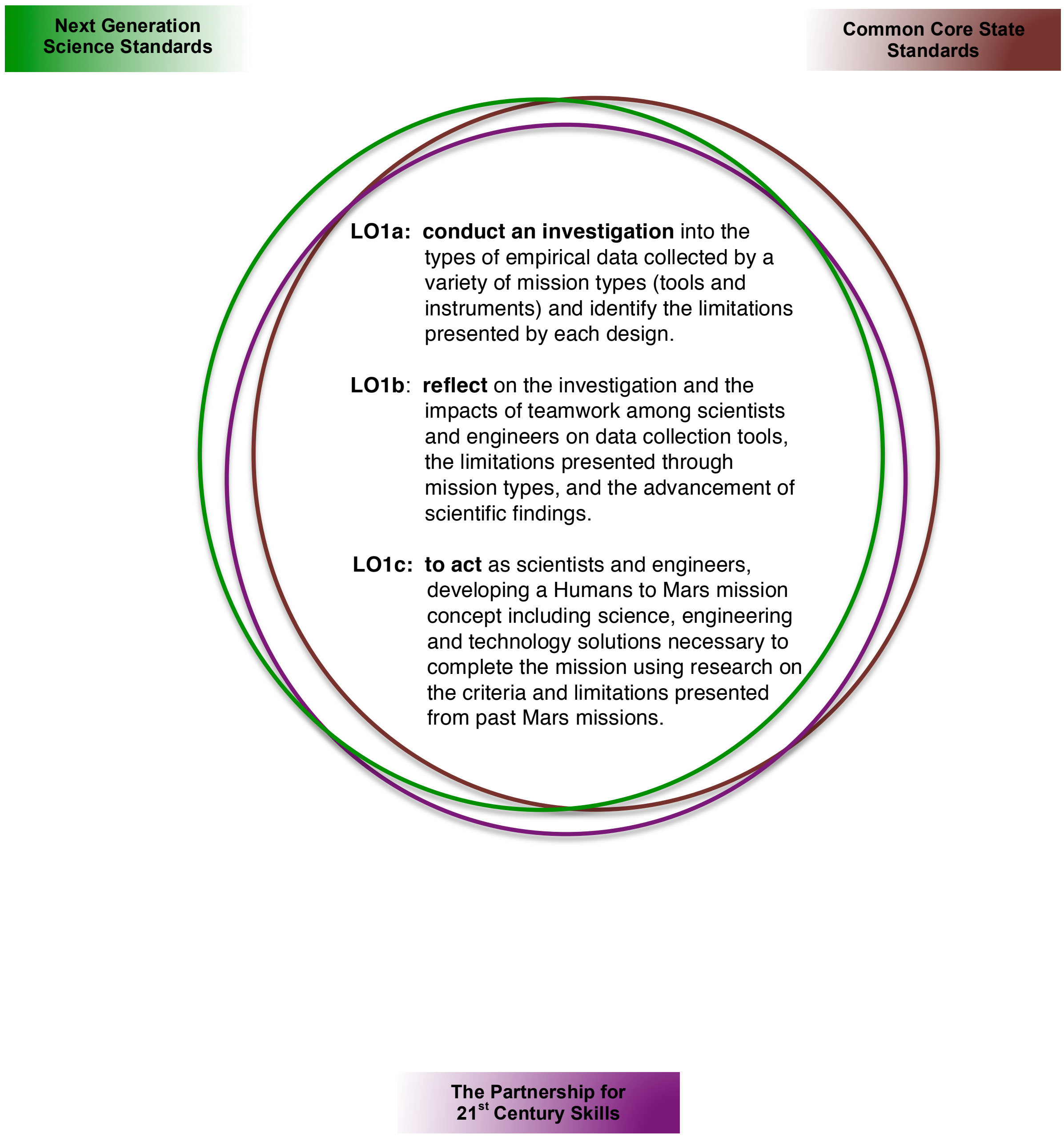
NGSS ETS1.A: Defining and Delimiting an Engineering Problem

Instructional Objective (IO) *Students will be able to:*	Learning Outcomes (LO) *Students will demonstrate the measurable abilities*	Standards *Students will address*
IO1: **use a physical model to investigate and describe how scientists and engineers understand the limitations presented through certain technologies and use a variety of increasingly complex tools to explore our solar system.**	**LO1a:** **conduct an investigation into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design.** **LO1b:** **reflect on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types, and the advancement of scientific findings** **LO1c:** **acting as scientists and engineers, develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions.**	**DISCIPLINARY CORE IDEAS:** **ETS1.A: Defining and Delimiting Engineering Problems** **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** **Scientific Investigations Use a Variety of Methods** **Scientific Knowledge is Based on Empirical Evidence** **Scientific Knowledge is Open to Revision in Light of New Evidence** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** **CROSSCUTTING CONCEPTS:** **1. Systems and System Models** **Interdependence of Science, Engineering, and Technology** **Science is a Way of Knowing** **Science is a Human Endeavor** **Science Addresses Questions about the Natural and Material World**

Last edited: March 31, 2016

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

Use the *(L) Strange New Planet Rubric* as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using the Next Generation Science Standards, Common Core State Standards, and 21st Century Skills.

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

(I) Teacher Resource. Strange New Planet 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)

Next Generation Science Standards Alignment (NGSS)

Instructional Objective *Students will be able to*	**Science and Engineering Practices**	**Disciplinary Core Idea**	**Crosscutting Concepts**
IO1: use a physical model to investigate and describe how scientists and engineers understand the limitations presented through certain technologies and use a variety of increasingly complex tools to explore our solar system	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **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. **Planning and Carrying Out Investigations:** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* Make observations and/or measurements to produce data to serve as the basis for evidence for an	**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)	**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. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks.

	explanation of a phenomenon or test a design solution. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. Record information (observations, thoughts, and ideas). *(Reconnection to K-2 Condensed Practices)* Use and share pictures, drawings, and/or writings of observations. *(Reconnection to K-2 Condensed Practices)* **Constructing Explanations and Designing Solutions:** Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts. *(Reconnection to 3-5 Condensed Practices)* **Scientific Investigations Use a Variety of Methods:** Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)*		Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Most scientists and engineers work in teams. *(Reconnection to 3-5 Crosscutting Statements)* Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.

	Scientific Knowledge is Based on Empirical Evidence: Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. Science findings are frequently revised and/or reinterpreted based on new evidence. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** Scientists use drawings, sketches, and models as a way to communicate ideas. *(Reconnection to K-2 Nature of Science)*		

(I) Teacher Resource. Strange New Planet NGSS Alignment (2 of 3)

Next Generation Science Standards Alignment (NGSS)

Learning Outcome *Students will be able to*	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: conduct an investigation into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design.	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **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. **Planning and Carrying Out Investigations:** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* 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. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. Record information (observations, thoughts, and ideas). *(Reconnection to K-2 Condensed Practices)* Use and share pictures, drawings, and/or writings of	**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)	**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. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.

	observations. *(Reconnection to K-2 Condensed Practices)* **Constructing Explanations and Designing Solutions:** Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **Scientific Investigations Use a Variety of Methods:** Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. Science findings are frequently revised and/or reinterpreted based on new evidence. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** Scientists use drawings, sketches, and models as a way to communicate ideas. *(Reconnection to K-2 Nature of Science)*		Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.
LO1b: Reflect on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types,	**Planning and Carrying Out Investigations:** Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**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	**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.

Last edited: March 31, 2016

and the advancement of scientific findings	**Constructing Explanations and Designing Solutions:** Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Scientific Investigations Use a Variety of Methods:** Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. Science findings are frequently revised and/or reinterpreted based on new evidence.	that are likely to limit possible solutions. (MS-ETS1-1)	Science and technology drive each other forward. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Most scientists and engineers work in teams. *(Reconnection to 3-5 Crosscutting Statements)* Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to

			observation and empirical evidence.
LO1c: Acting as scientists and engineers, develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions.	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **Planning and Carrying Out Investigations:** Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts. *(Reconnection to 3-5 Condensed Practices)* **Scientific Investigations Use a Variety of Methods:** Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate	**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)	**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. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Most scientists and engineers work in teams. *(Reconnection to 3-5 Crosscutting Statements)* Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can

	measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence.		be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.

(I) Teacher Resource. Strange New Planet NGSS 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
How Science and Engineering Come Together in Planetary Exploration	**Engage**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	**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)	**Interdependence of Science, Engineering, and Technology:** Science and engineering involve the use of tools to observe and measure things. (Reconnection to K-2 Disciplinary Core Idea Connections Statement) 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.
How Engineering and Technology Support Science Questions (Student Worksheets A – E)	**Explore**	**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. **Planning and Carrying Out Investigations:** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)*	**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)	**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. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)*

		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. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. Record information (observations, thoughts, and ideas). *(Reconnection to K-2 Condensed Practices)* Use and share pictures, drawings, and/or writings of observations. *(Reconnection to K-2 Condensed Practices)* **Constructing Explanations and Designing Solutions:** Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts. *(Reconnection to 3-5 Condensed Practices)*		**Systems and System Models:** Systems can be designed to do specific tasks. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.

		Scientific Investigations Use a Variety of Methods: Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. Science findings are frequently revised and/or reinterpreted based on new evidence. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** Scientists use drawings, sketches, and models as a way to communicate ideas. *(Reconnection to K-2 Nature of Science)* and ideas). Use and share pictures, drawings, and/or writings of observations. *(Reconnection to K-2 Condensed Practices)*		
How Engineering and Technology Support Answering Scientific Questions (Student	**Explain**	**Planning and Carrying Out Investigations:** Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**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	**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.

Worksheet F)		**Constructing Explanations and Designing Solutions:** Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Scientific Investigations Use a Variety of Methods:** Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence. Science findings are frequently revised and/or reinterpreted based on new evidence.	that are likely to limit possible solutions. (MS-ETS1-1)	Science and technology drive each other forward. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Most scientists and engineers work in teams. *(Reconnection to 3-5 Crosscutting Statements)* Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.

Planning a New Mission (Student Worksheet G)	**Elaborate**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. **Planning and Carrying Out Investigations:** Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts. *(Reconnection to 3-5 Condensed Practices)* **Scientific Investigations Use a Variety of Methods:** Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions.	**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)	**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. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Most scientists and engineers work in teams. *(Reconnection to 3-5 Crosscutting Statements)* Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)*

		(Reconnection to 3-5 Nature of Science) **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence.		Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.
Assessing Strengths and Weaknesses of Proposed Missions (Student Worksheet G, part 2)	**Evaluate**	**Planning and Carrying Out Investigations:** Evaluate appropriate methods and/or tools for collecting data. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings. **Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. **Obtaining, Evaluating, and Communicating Information:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts. *(Reconnection to 3-5 Condensed Practices)* **Scientific Investigations Use a Variety of Methods:**	**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)	**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. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies. *(Supporting statement from 3-5 Crosscutting Connections)* **Systems and System Models:** Systems can be designed to do specific tasks. **Science is a Way of Knowing:** Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. **Science is a Human Endeavor:** Most scientists and engineers work in teams. *(Reconnection to 3-5 Crosscutting*

		Science investigations use a variety of methods and tools to make measurements and observations. Science depends on evaluating proposed explanations. Science methods are determined by questions. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Based on Empirical Evidence:** Scientists use tools and technologies to make accurate measurements and observations. *(Reconnection to 3-5 Nature of Science)* **Scientific Knowledge is Open to Revision in Light of New Evidence:** Scientific explanations are subject to revision and improvement in light of new evidence.		*Statements)* Advances in technology influence the progress of science and science has influenced advances in technology. **Science Addresses Questions about the Natural and Material World:** Science findings are limited to what can be answered with empirical evidence. *(Reconnection to 3-5 Crosscutting Statements)* Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence.

(J) Teacher Resource. Strange New Planet CCSS Alignment (1 of 2)

Common Core State Standards

Instructional Objective *Students will be able to*	**Reading Standards for Literacy in Science and Technical Subjects (6-8)**	**Writing Standards for Literacy in Science and Technical Subjects (6-8)**	**Speaking and Listening Standards (6-8)**
IO1: **Use a physical model to investigate and describe how scientists and engineers understand the limitations presented through certain technologies and use a variety of increasingly complex tools to explore our solar system.**		**Text Types and Purposes:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. 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. b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style and objective tone. f. Provide a concluding	**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. a. 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. b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. **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. a. 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. b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as

		statement or section that follows from and supports the information or explanation presented. **Research to Build and Present Knowledge:** Draw evidence from informational texts to support analysis reflection, and research.	needed. c. 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. d. Acknowledge new information expressed by others and, when warranted, modify their own views. Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study. **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. a. 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. b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.

(J) Teacher Resource. Strange New Planet CCSS Alignment (2 of 2)

Common Core State Standards			
Learning Outcome *Students will be able to*	**Reading Standards for Literacy in Science and Technical Subjects (6-8)**	**Writing Standards for Literacy in Science and Technical Subjects (6-8)**	**Speaking and Listening Standards (6-8)**
LO1a: **conduct an investigation into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design.**		**Research to Build and Present Knowledge:** Draw evidence from informational texts to support analysis reflection, and research.	**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. a. 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. b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. **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. a. 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. b. Follow rules for collegial discussions, track progress toward

			specific goals and deadlines, and define individual roles as needed. c. 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. d. Acknowledge new information expressed by others and, when warranted, modify their own views. Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study. **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. a. 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. b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. c. 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.
LO1b: **reflect on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types, and the advancement of scientific findings**			**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. a. 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. b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text,

			or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. **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. a. 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. b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. c. 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. d. Acknowledge new information expressed by others and, when warranted, modify their own views. **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. a. 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. b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.
LO1c: **acting as scientists and engineers,**	**Craft and Structure:** Determine the meaning of symbols, key terms, and other domain-specific words	**Text Types and Purposes:** Write informative/explanatory texts, including the narration of historical	**Comprehension and Collaboration:** **Grade 6:** Engage effectively in a range of collaborative discussions (one-on-

develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions.	and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. **Integration of Knowledge and Ideas:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	events, scientific procedures/ experiments, or technical processes. a. 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. b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style and objective tone. f. Provide a concluding statement or section that follows from and supports the information or explanation presented. **Research to Build and Present Knowledge:** Draw evidence from informational texts to support analysis reflection, and research.	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. a. 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. b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. **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. a. 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. b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. c. 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. d. Acknowledge new information expressed by others and, when warranted, modify their own views. Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study. **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. a. 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. b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.

(J) Teacher Resource. Strange New Planet 21st Century Skills Alignment

21st Century Skills

Learning Outcomes *Students will demonstrate the measurable abilities*	**21st Century Skill**	**Grade 4 Benchmark**	**Grade 8 Benchmark**
LO1a: **conduct an investigation into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design.**	**Communication**	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		Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Critical Thinking and Problem Solving	Students construct their own scientific understanding and develop their scientific process skills by asking scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.	
	Information and Communications Technology (ICT) Literacy		Students can articulate how technology is essential to science for such purposes as sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
	Productivity and Accountability	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: **reflect on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types, and the advancement of scientific findings**	**Communication**	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		Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Critical Thinking and Problem Solving	Students construct their own scientific understanding and develop their scientific process skills by asking	

		scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.	
	Information and Communications Technology (ICT) Literacy		Students can articulate how technology is essential to science for such purposes as sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
	Flexibility and Adaptability	Students can identify how improvements in scientific instruments can lead to new discoveries.	
	Productivity and Accountability	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.	
	Social and Cross-Cultural Skills		Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.
LO1c: **acting as scientists and engineers, develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions.**	**Communication**	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		Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.
	Critical Thinking and Problem Solving	Students construct their own scientific understanding and develop their scientific process skills by asking scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.	
	Information and Communications Technology (ICT) Literacy		Students can articulate how technology is essential to science for such purposes as sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
	Flexibility and Adaptability	Students can identify how improvements in scientific instruments can lead to new discoveries.	
	Productivity and Accountability	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.	

(L) Teacher Resource. Strange New Planet 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: **conduct an investigation** into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design.	Collects multiple quantitative and qualitative data sets for each type of mission and records the data clearly. Identifies thoughtful questions left unanswered by the data from earlier missions and attempts to explore answers to them in subsequent missions.	Collects multiple quantitative and qualitative data sets for each type of mission and records the data clearly. Identifies one thoughtful question left unanswered by the data from earlier missions and attempts to explore answers to it in subsequent missions.	Collects and records quantitative or qualitative data for each type of mission. Asks some questions about the data from earlier missions that that may or may not be related to missions.	Collects data from peers and asks questions unrelated to the missions presented.
LO1b: to reflect on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types, and the advancement of scientific findings.	Provides a detailed explanation of the interdependence of scientists and engineers. Citing appropriate evidence, specifically the types of tools that match the type of desired science, from the activity and personal experience to support the explanation.	Provides a detailed explanation of the interdependence of scientists and engineers. Citing appropriate evidence from the activity to support the explanation.	Provides an explanation of the interdependence of scientists and engineers. Citing evidence from the activity to support the explanation.	States scientists and engineers work together and attempts to cite evidence from the activity.
LO1c: acting as scientists and engineers, develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions.	Clearly defines a Mars mission concept that incorporates important scientific goals in addition to choosing appropriate technology options to investigate the science goals.	Defines a Mars mission concept that incorporates scientific goals in addition to choosing appropriate technology options to investigate the science goals.	Defines a Mars mission concept that incorporates a scientific goal in addition to choosing an appropriate technology option to investigate the science goal.	Attempts to identify a science goal and match it to a technology option.

(L) Teacher Resource. Strange New Planet CCSS Rubric (2 of 3)

Common Core – ELA

	Expert	Proficient	Intermediate	Beginner
Craft and Structure	Determines and uses domain-specific words and phases from text to accurately support ideas.	Determines and uses domain-specific words and phrases from text to support ideas.	Uses domain-specific words and phrases from text with occasional errors to support ideas.	Uses standard language to support ideas.
Integration of Knowledge and Ideas	Uses a combination of drawing, dictating, and writing to provide a description of the results of the experiment, supported with evidence from the experiment and text or multimedia.	Uses a combination of drawing, dictating, and writing to describe the results of the experiment and text or multimedia.	Uses a drawing, dictation, or writing to describe the results of the experiment.	Description of the result is based on prior knowledge or preconceptions.
Text Type and Purposes	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.
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.
Comprehension and Collaboration	Clearly articulates ideas in collaborative discussion while following agreed upon class rules for discussion. Extremely prepared drawing from experiences. Asks clarifying questions to ensure full understanding of content. Articulates own ideas related to the discussion and connects others ideas to own.	Articulates ideas in collaborative discussion while following agreed upon class rules for discussion. Prepared for discussion by drawing from experiences. Asks questions. Articulates own ideas related to the discussion.	Interested in collaborative discussion. Asks questions. Articulates own ideas related to the discussion.	Interested in collaboration with peers.

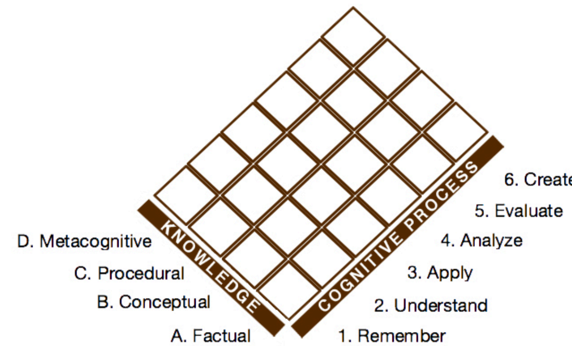
(L) Teacher Resource. Strange New Planet 21st Century Skills Rubric (3 of 3)

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 group or spend majority of the time off topic.
Effectiveness of Critical Thinking and Problem Solving	Develops detailed verbal explanations based on experimental evidence. Compares explanations to those made by peers and relates them to their new understandings.	Develops detailed verbal explanations based on experimental evidence. Relates them to their new understandings.	Develops verbal explanations. Relates explanation to their new understandings.	Attempts to explain the design based on own preconceived understanding or generally agree with the explanations provided by the group.
Effectiveness in Communication	Demonstrates the understanding that this is a simple model of how we explore, not all missions are represented, and communication is rooted in reality, not make-believe.	Demonstrates the understanding that this is a simple model of a how we explore, not all missions are represented, and may pretend the simulation is real, but majority of the experiment is rooted in reality.	Demonstrates the understanding that this is a simple model of how we explore and may pretend the simulation is real, but majority of the experiment is rooted in reality.	Plays during the simulation regardless of the goals of the task
Effectiveness of Productivity and Accountability	Accurately collects data and able to demonstrate good practices for data collection such as using standard measurement with correct tools **and** identifying common sources of error.	Accurately collects data and able to demonstrate good practices for data collection such as using standard measurement with correct tools **or** identifying common sources of error.	Accurately collects data.	Records data other team members have collected.
Effective use of Information and Communications Technology (ICT) Literacy	Gives examples that demonstrate how technology extends the ability of people to observe and understand planets including how people communicate, gain knowledge, and express ideas.	Gives examples that demonstrate how technology extends the ability of people to observe and understand planets including how people communicate, gain knowledge, or express ideas.	Gives one example to demonstrate how technology extends the ability of people to observe and understand planets.	Examples are based on preconceived misconceptions about the use of technology to extend the knowledge of people.
Effectiveness of Flexibility and Adaptability	Can accurately identify examples from the activity on how improvements in scientific instruments can lead to new discoveries.	Can accurately identify at least one example from the activity on how improvements in scientific instruments can lead to new discoveries.	Can identify at least one example from the activity on how improvements in scientific instruments can lead to more information.	Claims all scientific instruments will yield the same information or bases examples on preconceived misconceptions.

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

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



Knowledge	Cognitive Process
A. Factual	**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)

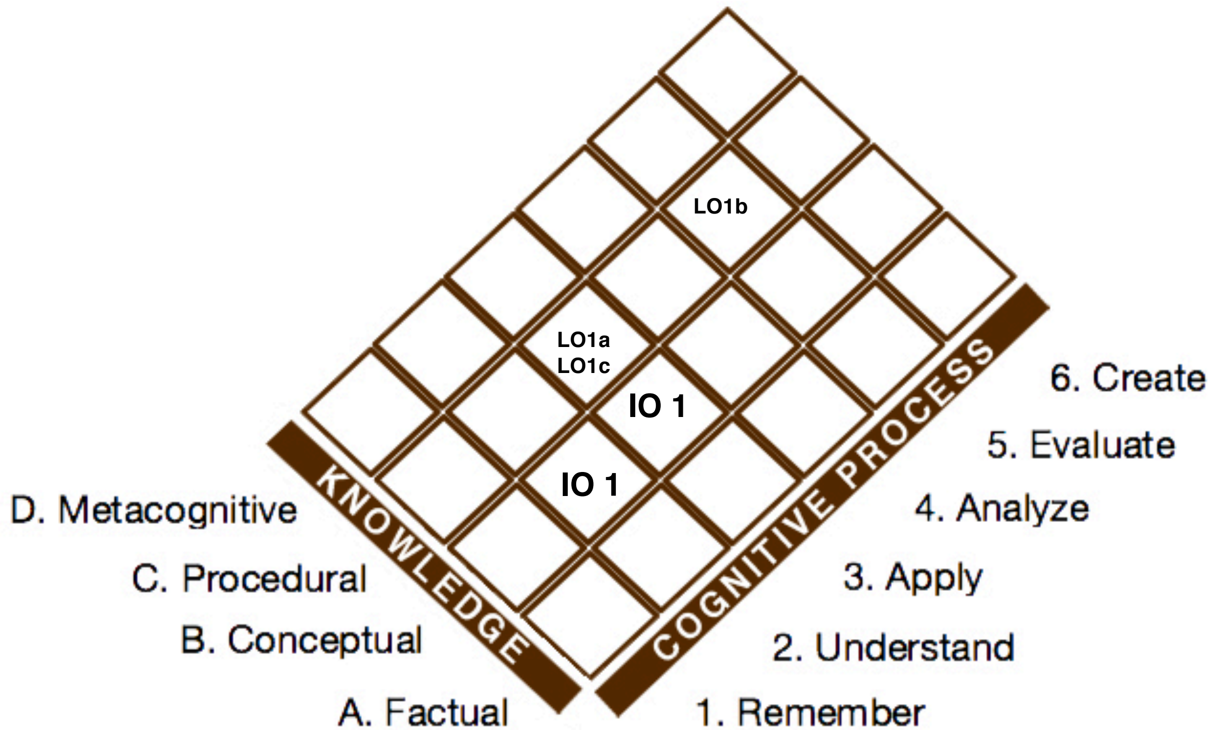
(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

IO1: use a physical model to **investigate and describe** how scientists and engineers understand the limitations presented through certain technologies and use a variety of increasingly complex tools to explore our solar system. (3.1, 2.7; Bc)

LO1a. **conduct an investigation** into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design. (3.1; Cb)

LO1b. **to reflect** on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types, and the advancement of scientific findings (5.2; Cb)

LO1c. **acting** as scientists and engineers, develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions. (3.1; Cb)



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

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Below are the knowledge and cognitive process types students are intended to acquire per the instructional objective(s) and learning outcomes written for this lesson. The specific, scaffolded 5E steps in this lesson (see 5.0 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 (M, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (M, 2 of 3) 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: use a physical model to **investigate and describe** how scientists and engineers understand the limitations presented through certain technologies and use a variety of increasingly complex tools to explore our solar system.

3.1: to carry out

2.7: to explain

Bc: Knowledge of theories, models, and structures

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

LO1a: **conduct an investigation** into the types of empirical data collected by a variety of mission types (tools and instruments) and identify the limitations presented by each design.

3.1: to conduct

Cb: Knowledge of subject-specific techniques and methods

LO1b: **to reflect** on the investigation and the impacts of teamwork among scientists and engineers on data collection tools, the limitations presented through mission types, and the advancement of scientific findings.

5.2: to critique

Cb: Knowledge of subject-specific techniques and methods

LO1c: **acting** as scientists and engineers, develop a Humans to Mars mission concept including science, engineering and technology solutions necessary to complete the mission using research on the criteria and limitations presented from past Mars missions.

3.1: to carry out

Cb: Knowledge of subject-specific techniques and methods