Arizona State University School of Earth and Space Exploration

SIMOC – Scalable, Interactive Model of an Off-world Community

Grades 5-8 Next Generation Science Standards, Common Core State Standards, and 21st Century Skills Alignment Document

WHAT STUDENTS DO: Use the SIMOC model to develop a habitat to support life off-world.

Students work with a model using authentic data gathered from decades of NASA and other science research on life support systems to develop a habitat to support at least 4 researchers on Mars or other off-world environments They will actively engage in creative critical thinking and iterative innovation through collaboration and persistence.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES (IO)
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*	*Students will be able to* **IO1: Use and modify a model limited by criteria and constraints to solve a complex science and engineering problem**
How and why do organisms interact with their environment and what are the effects of these interactions? *NGSS Core Question: LS2: Ecosystems: Interactions, Energy, and Dynamics* How do organisms interact with the living and nonliving environments to obtain matter and energy? *NGSS LS2.A: Interdependent Relationships in Ecosystems* How do matter and energy move through an ecosystem?	**IO2: Plan and conduct investigations using models to understand and test the interdependence of biotic and abiotic components of an ecosystem**

NGSS LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

What happens to the ecosystems when the environment changes?

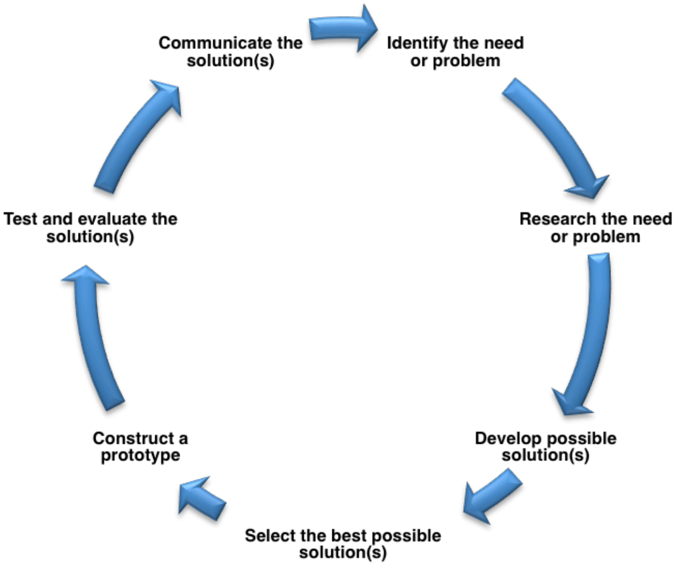
NGSS LS2.C: Ecosystem Dynamics, Functioning, and Resilience

1.0 About This Activity

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.

The format for developing a question was guided by statements made by Bybee in "Scientific and engineering practices in K-12 classrooms: Understanding a framework for K-12 science education" publish by NSTA. Here Bybee explained that the term "practices" was a much more accurate explanation of scientific inquiry. These practices "involve doing and learning in such a way that cannot be really separated." The process for reaching a scientific research question in this lesson has been discussed and vetted through planetary scientists actively involved in research.

Additionally, students engage in an engineering design activity using SIMOC. They use the engineering design process to solve problems associated with living on Mars and doing exploration and research for an extended period of time. A brief description of the engineering design process can be seen in this diagram. This design, along with the 5E Instructional Model, provides the organization for the activities.



2.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

Instructional objectives and learning outcomes are aligned with

- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- National Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- 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 NRC Framework and NGSS.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO),** also aligned with NGSS Framework and NGSS.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics**.

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:

This alignment document provides full details of standards alignment, and the way in which instructional objectives, learning outcomes, 5E activity procedures, and assessments were integrated to ensure maximal learning. For convenience, a quick view follows:

The following are the Disciplinary Core Ideas most associated with these lessons.

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

How and why do organisms interact with their environment and what are the effects of these interactions?

NGSS Core Question: LS2: Ecosystems: Interactions, Energy, and Dynamics

How do organisms interact with the living and nonliving environments to obtain matter and energy?

NGSS LS2.A: Interdependent Relationships in Ecosystems

How do matter and energy move through an ecosystem?

NGSS LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

What happens to the ecosystems when the environment changes?

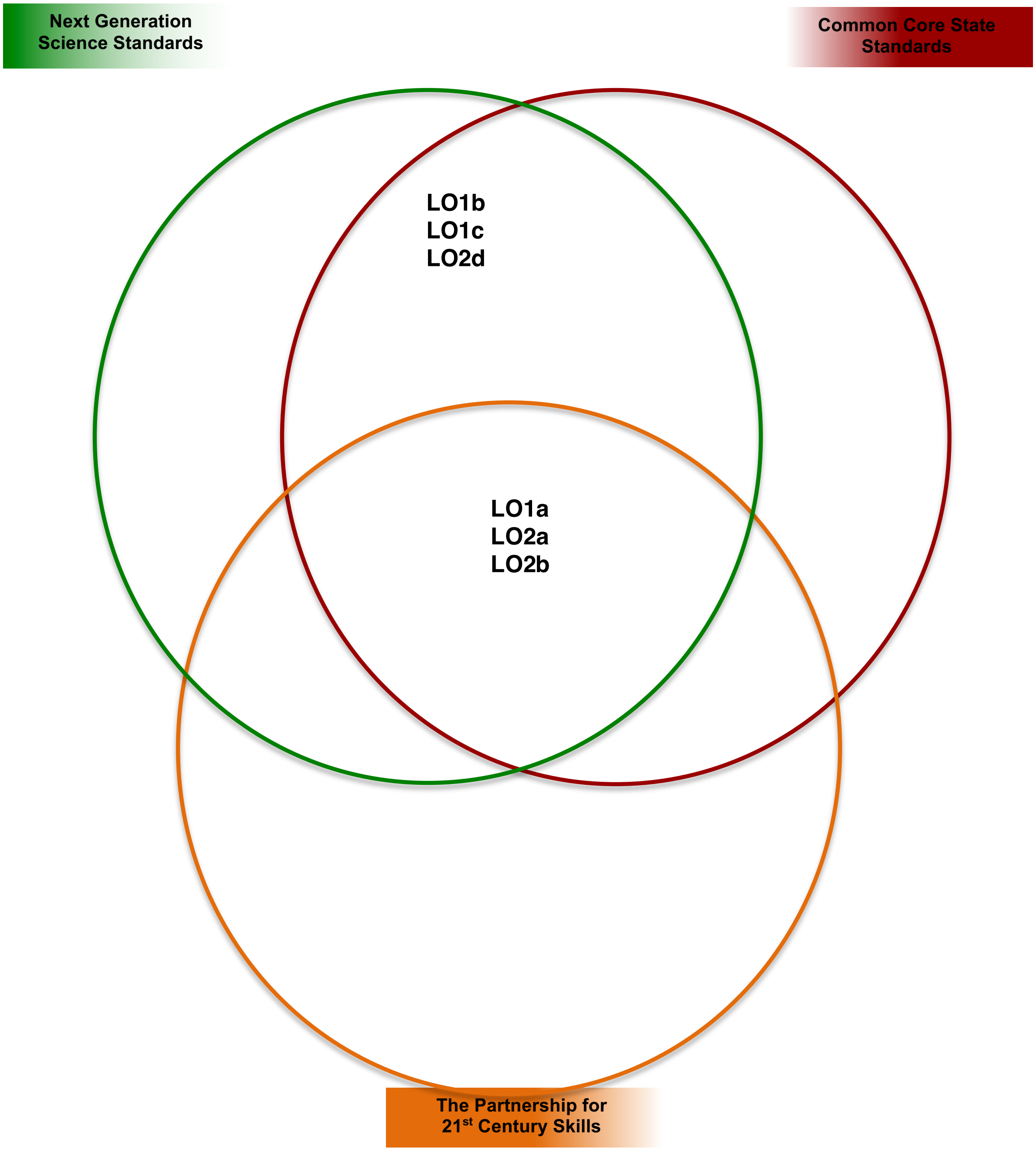
NGSS LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Instructional Objective *Students will be able to*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*	
IO1: **Use and modify a model limited by criteria and constraints to solve a complex science and engineering problem**	**LO1a: to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution using tools (instruments) to achieve the mission goal** **LO1b: to identify and explain the specific components of the engineering design cycle for the designed model** **LO1c: 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** **PS4.C: Information Technologies and Instrumentation** **PRACTICES:** **1. Asking Questions and Defining Problems** **2. Developing and Using Models** **3. Planning and Carrying Out Investigations** **4. Analyzing and Interpreting Data** **5. Using mathematics and computational thinking** **6. Constructing Explanations and Designing Solutions** **7. Engaging in Argument from Evidence** **CROSSCUTTING CONCEPTS:** **1. Cause and Effect** **2. Systems and System Models** **3. Energy and Matter** **4. Structure and Function** **5. Stability and Change** **Science is a Human Endeavor**	***Rubrics in SIMOC Lesson***

Instructional Objective *Students will be able to*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*	
IO2: **Plan and conduct investigations using models to understand and test the interdependence of biotic and abiotic components of an ecosystem**	**LO2a: to ask questions that can be investigated and that define a design problem to identify how humans are dependent on environmental interactions with other living things and nonliving factors in a system** **LO2b: to plan and conduct an investigation into maintaining a healthy ecosystem in a closed system by tracking the flow of matter and energy** **LO2c: to use and modify a model using evidence to establish stability over time in a dynamic engineered ecosystem** **LO2d: to construct an explanation that includes qualitative and quantitative relationships using models of systems** showing that organisms survive by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.	**DISCIPLINARY CORE IDEA:** **LS2.A: Interdependent Relationships in Ecosystems** **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** **PRACTICES:** **1. Asking Questions and Defining Problems** **2. Developing and Using Models** **3. Planning and Carrying Out Investigations** **4. Analyzing and Interpreting Data** **5. Using mathematics and computational thinking** **6. Constructing Explanations and Designing Solutions** **7. Engaging in Argument from Evidence** **8. Obtaining, Evaluating, and Communicating Information** **CROSSCUTTING CONCEPTS:** **1. Cause and Effect** **2. Systems and System Models** **3. Energy and Matter** **4. Structure and Function** **5. Stability and Change** **Science is a Human Endeavor**	***Rubrics in SIMOC Lesson***

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 *(N) Design Rubrics* as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. There are several different rubrics that you can use depending on the focus of your class and your goals.

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.

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.o

(M) Teacher Resource. SIMOC NGSS Alignment (1 of 5)

Related Standard(s)

This lesson supports the preparation of students toward achieving Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below:

(MS-ETS1-1), (MS-ETS1-2), (MS-ETS1-3);
(MS-LS2-1), (MS-LS2-3), (MS-LS2-4);

Next Generation Science Standards Alignment (NGSS)

Instructional Objective	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO1: **Use and modify a model limited by criteria and constraints to solve a complex science and engineering problem**	**Asking Question and Defining Problems:** Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. **Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Systems and System Models** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information

	Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Analyzing and Interpreting Data:** Analyze and interpret data to provide evidence for phenomena. Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Using Mathematical and Computational Thinking:** Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. **Constructing Explanations and Designing Solutions:** Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. **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 a model for a phenomenon or a solution to a problem.	solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2)	flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study. **Energy and Matter:** They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system. **Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. **Stability and Change:** Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time

(M) Teacher Resource. SIMOC NGSS Alignment (2 of 5)

Next Generation Science Standards Alignment (NGSS)

Instructional Objective	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO2: **Plan and conduct investigations using models to understand and test the interdependence of biotic and abiotic components of an ecosystem**	**Asking Question and Defining Problems** Ask questions that can be investigated and predict reasonable outcomes based on patterns … Use prior knowledge to describe problems that can be solved. **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:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	**LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) **LS2.B: Cycles of Matter and Energy in Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Systems and System Models** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.

	Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena. Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Using Mathematical and Computational Thinking:** Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. **Constructing Explanations and Designing Solutions:** Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. **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 a model for a phenomenon or a solution to a problem. **Obtaining, Evaluating, and Communicating Information** Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4)	**Energy and Matter:** They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system. **Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. **Stability and Change:** Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time

	describe how they are supported or not supported by evidence.		

(M) Teacher Resource. SIMOC NGSS Alignment (3 of 5)

Next Generation Science Standards Alignment (NGSS)

Learning Outcomes	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution using tools (instruments) to achieve the mission goal	**Asking Question and Defining Problems:** Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. **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:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Analyzing and Interpreting Data:** Analyze and interpret data to provide evidence for phenomena.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3) **LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) **LS2.B: Cycles of Matter and Energy in Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so	**Systems and System Models:** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study. **Energy and Matter:** They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system. **Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes,

	Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Obtaining, Evaluating, and Communicating Information** Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	are waste products, such as fecal material. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4)	composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. **Stability and Change:** Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time
LO1b: to identify and explain the specific components of the engineering design cycle for the designed model	**Constructing Explanations and Designing Solutions:** Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. **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 a model for a phenomenon or a solution to a problem. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Systems and System Models** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited

		that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2)	in that they only represent certain aspects of the system under study.
LO1c: to identify and explain the complex relationship between science and engineering design	**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:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **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 a model for a phenomenon or a solution to a problem. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2)	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Systems and System Models** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study. **Stability and Change:** Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable

			due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time

(M) Teacher Resource. SIMOC NGSS Alignment (4 of 5)

Next Generation Science Standards Alignment (NGSS)

Learning Outcomes	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO2a: to ask questions that can be investigated and that define a design problem to identify how humans are dependent on environmental interactions with other living things and nonliving factors in a system	**Asking Question and Defining Problems** Ask questions that can be investigated and predict reasonable outcomes based on patterns … Use prior knowledge to describe problems that can be solved.	**LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4)	**Systems and System Models:** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.

LO2b: to plan and conduct an investigation into maintaining a healthy ecosystem in a closed system by tracking the flow of matter and energy	**Planning and Carrying Out Investigations:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Analyzing and Interpreting Data:** Analyze and interpret data to provide evidence for phenomena. Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. **Using Mathematical and Computational Thinking:** Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.	**LS2.B: Cycles of Matter and Energy in Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4)	**Energy and Matter:** They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system. **Stability and Change:** Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time
LO2c: to use and modify a model using evidence to establish stability over time in a dynamic engineered ecosystem	**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:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **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 a model for a	**LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) **LS2.B: Cycles of Matter and Energy in Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	**Stability and Change:** Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time

	phenomenon or a solution to a problem. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4)	
LO2d: to construct an explanation that includes qualitative and quantitative relationships using models of systems showing that organisms survive by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.	**Analyzing and Interpreting Data:** Analyze and interpret data to provide evidence for phenomena. **Using Mathematical and Computational Thinking:** Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. **Constructing Explanations and Designing Solutions:** Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. **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 a model for a phenomenon or a solution to a problem.	**LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) **LS2.B: Cycles of Matter and Energy in Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. (MS-LS2-4)	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function.

(M) Teacher Resource. SIMOC NGSS Individual Activity Alignment (5 of 5)

Next Generation Science Standards Activity Alignments (NGSS)

Activity	Phases of 5E Instructional Model	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Designing the Habitat	**Engage**	**Asking Question and Defining Problems** Ask questions that can be investigated and predict reasonable outcomes based on patterns … Use prior knowledge to describe problems that can be solved.	**LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)	**Systems and System Models:** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.
Researching the Problem	**Explore**	**Asking Questions and Defining Problems:** Ask questions to clarify and/or refine a model, an explanation, or an engineering problem. **Obtaining, Evaluating, and Communicating Information:** Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**LS2.B: Cycles of Matter and Energy in Ecosystems:** Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	**Systems and System Models:** Systems can be designed to do specific tasks. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Developing Possible Solutions and Selecting the Best Solution	**Explore** **Explain**	**Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. Evaluate limitations of a model for a proposed object or tool. **Planning and Carrying Out Investigations:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **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 a model for a phenomenon or a solution to a problem.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3)	**Systems and System Models:** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study. **Energy and Matter:** They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.
Constructing a Prototype Design, Part 1	**Explore** **Explain**	**Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be	**Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function.

			able to communicate and explain solutions to others. (MS-ETS1-3)	
Evaluating the Solution, Part 1	**Evaluate**	**Constructing Explanations and Designing Solutions:** Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2)	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
Communicating the Solution, Part 1	**Explain**	**Constructing Explanations and Designing Solutions:** Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its	**Systems and System Models:** Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.

			predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2) systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	
Evaluating the Solution, Part 2	**Evaluate**	**Constructing Explanations and Designing Solutions:** Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2)	**Cause and Effect:** They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
Constructing a Prototype Design, Part 2	**Elaborate/Extend**	**Developing and Using Models:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes	**Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts.

			consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3)	They analyze many complex natural and designed structures and systems to determine how they function.
Evaluating the Solution, Part 3: Running the SIMOC Simulation	**Elaborate** **Explore** **Evaluate**	**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:** Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Analyzing and Interpreting Data:** Analyze and interpret data to provide evidence for phenomena. **Using Mathematical and Computational Thinking:** Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends	**ETS1.A: Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. (MS-ETS1-3) **ETS1.C: Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This	**Structure and Function:** Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function.

			iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (MS-ETS1-2) **LS2.A: Interdependent Relationships in Ecosystems:** Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)	
Understanding the Science and Engineering Practices and the Crosscutting Concepts				

(M) Teacher Resource. SIMOC CCSS Alignment

Instructional Objective	Reading Standards for Literacy in Science and Technical Subjects (5-8)	Writing Standards for Literacy in Science and Technical Subjects (5-8)
LO1b: **to identify and explain the specific components of the engineering design cycle for the designed model** **LO1c:** **to identify and explain the complex relationship between science and engineering design** **LO2d:** **to construct an explanation that includes qualitative and quantitative relationships using models of systems** showing that organisms survive by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.	**Key Ideas and Details:** **Grade 6-8:** Cite specific textual evidence to support analysis of science and technical texts. **Integration of Knowledge and Ideas** **Grade 6-8:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **Grade 6-8:** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. **Grade6-8:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	**Text Types and Purposes:** **Grade 6-8:** Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. **Grade 6 - 8:** Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. **Research to Build and Present Knowledge** **Grades 6-8:** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

(M) Teacher Resource. SIMOC Partnerships for 21st Century Skill Alignment

21st Century Skills

Learning Outcomes	21st Century Skill	Outcomes
LO1a: to analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution using tools (instruments) to achieve the mission goal	**Collaboration**	Collaborate with others
	Critical Thinking and Problem Solving	Reason effectively and solve problems
	Flexibility and Adaptability	Adapt to change
LO2a: to ask questions that can be investigated and that define a design problem to identify how humans are dependent on environmental interactions with other living things and nonliving factors in a system	**Collaboration**	Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.
	Critical Thinking and Problem solving	Reason effectively and solve problems
	Flexibility and Adaptability	Adapt to change
LO2b: : to plan and conduct an investigation into maintaining a healthy ecosystem in a closed system by tracking the	**Media literacy**	Analyze media

flow of matter and energy		
	Creativity and innovation	Think creatively, work creatively with others, and implement solutions.
	Critical Thinking and problem solving	Reason effectively and solve problems

(N) Teacher Resource. SIMOC NGSS Rubrics

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 analyze criteria and constraints in an engineering design task and collect data to generate and refine an appropriate solution using tools (instruments) to achieve the mission goal	Design criteria and constraints take into account the complexity of interacting systems. Modifies design as data is collected and analyzed.	Design criteria and constraints identify the correct subsystems and interactions. Moderately modifies design using data collected.	Design is one system. Modifications to design are random..	Design reflects personal interest.
LO1b: to identify and explain the specific components of the engineering design cycle for the designed model	Concise and thorough explanation takes into account the complex interaction between sub-systems and the complexity of the design process as data input refined design.	Explanation describes the subsystems and the iteration within design modifications	Explanation describes the overall system and the steps of the design process.	Explanation describes the impact on them as they proceeded through the design cycle.
LO1c: to identify and explain the complex relationship between science and engineering design	Concisely and thoroughly explains the complex relationship between the requirements of living things and design of the model to supply the requirements in subsystems.	Explanation includes the relationship between the science and the engineering design.	Explanation focuses on the design model.	Describes how the resulting model would take care of their personal needs.

LO2a: to ask questions that can be investigated and that define a design problem to identify how humans are dependent on environmental interactions with other living things and nonliving factors in a system	Develops researchable questions that guide investigations into the dependence of humans on complex ecosystems.	Asks questions about the interdependence of living and non-living systems.	Asks questions about the needs of humans.	Asks questions that are centered on their interests.
LO2b: to plan and conduct an investigation into maintaining a healthy ecosystem in a closed system by tracking the flow of matter and energy	Investigations accurately control variables of matter, energy and elements of subsystem for creating healthy, self-sustaining ecosystems.	Investigations measures the matter and energy of ecosystems.	Investigations monitor the survival of elements of the ecosystem.	Investigations observe ecosystems.
LO2c: to use and modify a model using evidence to establish stability over time in a dynamic engineered ecosystem	Uses and modifies the model from evidence to achieve stability in a dynamic engineered ecosystem.	Uses and modifies the SIMOC model to generate data. Attempts to have stability.	Uses and modifies the SIMOC model to generate data.	Makes random choices in the SIMOC environment.
LO2d: to construct an explanation that includes qualitative and quantitative relationships using models of systems showing that organisms survive by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.	Constructs a complete and coherent explanation of the modifications to the SIMOC model that are qualitative and quantitative that demonstrates how a stable ecosystem could be developed by taking into account the interdependencies of the organisms in the systems.	Constructs an explanation of how modifications to the SIMOC model resulted in different outcomes. Explanation is mostly qualitative with some quantitative analysis to describe interdependency of humans on the subsystems.	Describes the modifications to the SIMOC model and describes the outcomes. Suggests a possible ideal configuration.	Describes what happened during the SIMOC trials and the team reacted to the outcomes.