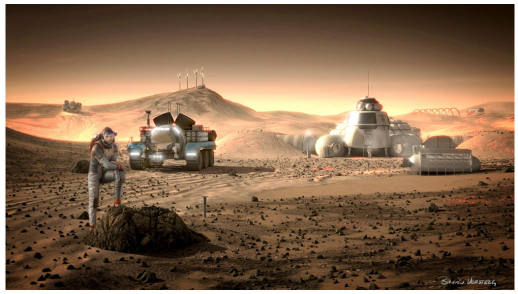
SIMOC – Scalable, Interactive Model of an Off-world Community

Grades: 5 - 8 Prep Time: ~30 Minutes Lesson Time: Varies Based on Project



Teacher Guide

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 science research on life support systems to develop a habitat to support researchers on Mars or other off-world environments They will actively engage in creative critical thinking and iterative innovation through collaboration and persistence.

NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES
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*	***Students will be able to:*** **IO2: Plan and conduct investigations using models to understand and test the interdependence of biotic and abiotic components of an ecosystem**

Required Materials

Please Print:

From Student Guide:

A	Designing the Habitat	1 per student
B	Researching the Problem	1 per student
C	What is Mars Really Like	1 per student
D	What are Sub-systems that Can be Used in Habitats to Support Humans	1 per student
E	Credible Sources Evaluation	2-3 per group
F	Brainstorm Possible Design Solutions	2 per group
G	Daily Reflection Sheet	1 per group
H	Engineering Design Cycle Defined	1 per student
I	Engineering Design Cycle Team Summary	1 per student
J	About Your Habitat	1 per student
K	About the Engineering Cycle	1 per student
L	About Your Thinking	1 per student
M	Reflection on Practices and Crosscutting Concepts	1 per group
N	Design Rubrics	1 per group

General Resources:

- HERA- Human Exploration Research Analog: https://www.nasa.gov/analogs/hera
- UA Controlled Environment Agriculture Center Prototype Lunar Greenhouse: https://cals.arizona.edu/lunargreenhouse/

- International Space Station: Hadfield videos: https://blogs.scientificamerican.com/psi-vid/top-10-commander-chris-hadfield-videos-from-the-iss/
- International Space Station: https://www.spacestationexplorers.org/news-media/videos/
- International Space Station Updates: https://www.nasa.gov/mission_pages/station/main/index.html#.VMFqksZ4hSs
- A Framework for K-12 Science Education: https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts
- Next Generation Science Standards: https://www.nextgenscience.org/
- BSCS 5E Instructional Model: https://bscs.org/bscs-5e-instructional-model

2.0 Vocabulary — Teacher Guide

Criteria	a standard list of "rules" established so judgment or decisions are based on objective and defined ideas rather than subjective ones.
Data	facts, statistics, or information.
Empirical Evidence	knowledge gained through direct or indirect observation.
Engineering	a field in which humans solve problems that arise from a human need or desire by relying on their knowledge of science, technology, engineering design, and mathematics (derived from NRC Framework, 2012).
Engineering Constraints	limits placed on a project by the budget, hardware, available volume or mass, etc. necessary to accomplish the mission.
Explanations	logical descriptions applying scientific information
Models	a scientific model is a physical, conceptual, or mathematical representation of a real phenomenon. Models are used to explain and predict the behavior of real phenomena.
Observations	specific details recorded to describe an object or phenomenon.
Terrain	a stretch of land, especially with regard to its physical features or geology.
Systems	a system is an organized group of related objects or components that form a whole. Systems can consist, for example, of organisms, machines, fundamental particles, galaxies, ideas, and numbers. Systems have boundaries, components, resources, flow, and feedback. (National Science Education Standards)
Sub-System	a component of a system that is itself a system.

Introduction

Earth provides many complex, interacting systems that recycle matter and energy, and in the process recycle water, maintain the atmosphere, recycle chemicals that are essential to life, and maintain temperatures appropriate for life. Researchers are working to understanding the full complexity of the interacting ecosystems and the dynamical interactions of all living (biotic) and non-living (abiotic) elements of life.

For more than a century people have wondered and experimented with how humans could live under water on this planet, or on other worlds. Scientists and engineers, often working with the support of government programs such as the European Space Agency, Roscomos, NASA, and university programs around the world, have developed pressure suits, vehicles for space travel, and orbital space stations. Each of these *sealed containers* provide a habitat to support human life for various durations, in otherwise harsh conditions of minimal or no atmosphere, extreme temperatures, and harmful radiation.

From 1991 to 1993 eight humans lived in the Biosphere 2 (B2), outside of Oracle, Arizona. B2 was a completely self-sustaining, sealed environment that houses a half acre farm, rain forest, savanna, ocean, marsh, and desert. Many valuable lessons were learned in those two years, including the impact of the microbiome on the balance of oxygen and carbon dioxide, and how the human built environment, in particular concrete can have long-lasting effects on the breathable atmosphere.

SIMOC is a scalable, interactive model of an off-world community, a computer model built upon authentic data from decades of research in mechanical and biological life support systems. It is composed of a web-based interface to a powerful computational engine, providing a platform for both research and education.

The goal is to design the most effective system to support human life for extended periods of time off-Earth. The habitat is a system made of many sub-systems that must work together to provide humans with safe and healthy living conditions.

SIMOC provides an authentic science model based on the best information available today. Oxygen, carbon dioxide, and methane; water vapor, potable and waste water, plant growth, and electrical power production and consumption are all included in the SIMOC simulation of an off-world human community.

Users select from a list of available subsystems to create their own model habitat and then run a simulation of how that model functions over time. Advanced users can custom program plants with unique properties for carbon dioxide removal or higher yields of food production, or solar panels that provide more electrical power.

To gain a better understanding of *SIMOC*, please visit https://simoc.space/ and watch the introduction video.

Not only is *SIMOC* designed for active science and engineering research, but *SIMOC* is designed for K-12 formal education students and citizen scientists to use to do meaningful research as well. This Teacher Guide and the Student Guide are carefully constructed to provide the scaffolding to prepare students to use *SIMOC* in their own research and learning. The *SIMOC* lesson is aligned to *A Framework for K-12 Science Education* and *Next Generation Science Standards (NGSS).* Students can engage in authentic science as they learn and apply key ideas about matter, energy, ecosystems, and engineering.

Students will engage in an engineering design activity using *SIMOC*. They will 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. A more detailed description is in Activity E in the Student Guide.

Preparing to use SIMOC

Students are unlikely to be ready to begin using *SIMOC* without some preparation. A series of activities has been designed to prepare students to engage in authentic science using *SIMOC*. These activites provide a scaffold to support student understanding of the key variables that can be controlled with *SIMOC*. The activities help students identify key aspects of an environment that can sustain human life. This understanding can be applied to Earth or the engineered environment of an off-world habitat. After completing these activities, students will be ready to use the SIMOC science model to design a more authentic habitat.

These activites are organized by the phases of the engineering design process to make this process more overt. The activities are also organized by the 5E Instructional Model.

Defining the Problem

Designing the Habitat

The scaffolding activity, *Designing the Habitat*, is the phenomenon that the students will need to understand to be able to design a habitat to support researchers on Mars. There are two major constraints on the design process.

1. They are designing a habitat to be used on Mars within 25 to 50 years. This keeps the process relevant and avoids a “science fiction” solution of a habitat 500 years in the future.
2. Cost is always a constraint. Although we are not identifying a budget, it is best to keep costs as low as possible. One big cost is the launch of materials from Earth. The current range of costs is $10,000 to $20,000 **per kilogram** and the Curiosity rover cost as much as $2.78 <u>million</u> per kilogram. So, a huge habitat on Mars might be attractive, but it would be very costly. Scientists will probably work for the smallest mass (in kilograms) habitat that will accomplish the mission.

Print and distribute Resource (A) *Designing the Habitat* from the Student Guide. As students consider the problems posed by *Designing the Habitat*, they identify the criteria and constraints that will drive their design for a habitat. Have them read the first two paragraphs and encourage them to ask clarifying questions so they understand the basic situation. Then move them into a more structured discussion in Step 1.

Teacher Tip: A very effective and dramatic way to introduce this is to get the class quiet and then loudly and firmly close the door. Then tell them that they have just been sealed in the classroom and nothing can get in or out and they must survive for several weeks or months. Start them asking questions and then have them read *Designing the Habitat* and move to the more structured Step 1.

Step 1 of *Designing the Habitat* activity is also the Engagement phase of the 5E Instructional Model. As the engagement phase, the activity engages student interest in the essential problem; **and** it elicits prior knowledge, naïve understandings and unresolved questions. In this case the students have to identify requirements for life. Different age groups will have different depths of understanding. They should identify the following criteria or requirements at a minimum:

- Breathable air
- Drinkable water
- Food
- Waste disposal
- Energy
- Protection

Gently guide students to develop questions like; how will we provide air, how will we provide clean water, how will we get food, and so on. It is important for them to generate questions rather than a list of requirements for life. The questions get them to think more deeply about how we do this on Earth and how they might solve the problem for a sealed room.

Step 2 of *Designing the Habitat* activity establishes the scope of the actual design problem. Designing a research station on Mars breaks down into 2 major components:

- How do you design a habitat that will provide life support for the researchers?
- How do you design an environment that promotes health and emotional support in an alien environment?

Designing the habitat can be separated into separate sub-systems such as; providing food, providing clean water, disposing of waste, etc. Students discuss what problems or parts of problems for which they want to design solutions.

Teacher Tip: Keep in mind that the problems can vary. Some can be very large, some more general, and yet others very small and specific. The class could potentially identify a larger problem while individual teams work on smaller problems that are building blocks to solve the larger problem. Identifying the problem to solve will focus the task as students move forward. Help students choose reasonable projects for the time they have.

Researching the Problem

The second step in the engineering design cycle is researching the problem. Research helps to fill in caps in students' prior knowledge and imagination and will improve accuracy of design. This is the Research phase of the Engineering Design cycle and the Explore phase of the 5E Instructional Model.

The first step for the students is to identify questions they have about the project they will design to guide their research. Print and distribute Resource (B) *Researching the Problem* from the Student Guide. Students are asked to generate and record their questions. This is an opportunity to elicit prior knowledge, misconceptions, and unresolved questions.

Students are reminded that conditions on Mars may affect their design. Some of the questions about Mars they should identify are:

a. What are the temperatures like on Mars?
b. What is the terrain like?
c. What kind of atmosphere is there on Mars?
d. Is there water and food on Mars?

A basic understanding of the Martian atmosphere and raw materials will provide a solid foundation to move the project forward and a stepping-stone for background research to learn more.

Other questions will be specific to the problem they are trying to solve.

If they are designing a way to provide air to breathe in the habitat, they might ask

a. What is the composition of air on Earth?
b. How do we maintain the right composition of air on Earth?
c. Could we use some of the same techniques in a closed habitat?
d. Has NASA worked on any designs that could guide us?

If they are designing a way to provide drinkable water, they might ask:

a. How much water does a person need every day?
b. How does Earth provide produce clean water and recycle impure water?
c. Can this be done in a closed habitat?
d. Has NASA designed any systems to provide clean water in a closed habitat?

Three resources have been provided for the students to help in their research. Print and distribute Resources C: *What is Mars Really Like?* , Resource D: *What are Sub-systems that can be Used in a Sealed Habitat to Support Humans*, and Resource E: *Credible Sources Evaluation* from the Student Guide.

Resource D: *What are Sub-systems that Can be Used in a Sealed Habitat to Support Humans* will provide structure for their research on types of sub-systems that have been developed to recycle air and water and provide energy, food and protection.

Teacher Tip: Resource D introduces the idea of a system and a sub-system. This would be a good time to discuss what a system is and what a sub-system is. There is a definition in the Vocabulary section. One familiar system is their home. It is made of many sub-systems: a water heater; air conditioner; heater; plumbing with sinks, showers and drains; toilet and sewer; roof, window, and walls, etc. Each sub-system can be examined in detail to see how it contributes to the system (home) and other sub-systems.

Resource C: *What is Mars Really Like?* will provide an opportunity to research critical information about Mars that impacts their habitat.

The quality of resources on the Internet can vary greatly. Resource D: *Credible Sources Evaluation* will help students separate credible from non-credible Internet resources. This is a great resource that you may wish to use on other projects.

Developing Possible Solutions and Selecting the Best Solution

The next phases of the engineering design are to develop possible solutions and select the best solution. This is also a continuation of the Explore phase of the 5E Instructional Model and moves into the Evaluate phase. Print and distribute Resource E: *Design Possible Design Solutions* and Resource F: *Daily Reflection Sheet* (students will begin using the *Daily Reflection Sheet* each day). Have students brainstorm possible solutions and record their results. When the students have several different solutions, have them evaluate the possible solutions to select the best solution that they will use to design their prototype (Evaluate).

Constructing a Prototype Design, Part 1

Constructing the design is where the students begin to grapple with the details of the design. Engineers call this a prototype design. It is something to start with to help them identify strengths and weaknesses of the design. They don't have to physically construct a 3-dimensional model of their proposed habitat with all of the sub-systems identified. Often engineers will draw the protptype or model (often using Computer Aided Design (CAD) software) and describe the design in drawings and words as carefully as they can. This is what the students are asked to do.

Hand out Resource J: *About Your Habitat* and have them work together to draw the habitat with all sub-systems and how the sub-systems work together. Then have them describe the habitat in writing.

Teacher Tip: If you have the time and you are interested in Maker activities, students could construct a 3-dimensional model using very simple materials such as, boxes, straws, pipe cleaners, used CD's, plastic plants, foil, etc.

Teacher Tip: Resource L: *About Your Habitat* will be used several times because students can create several versions based on feedback. In the next step (Evaluating the Solution) each group will evaluate their own prototype habitat, and they may make changes before they communicate their prototype to the other teams. Based on feedback from the other teams, they may revise the prototype again. When they begin the SIMOC simulation, they may find that some of their chosen design elements are not available among the SIMOC options; causing them to revise again. After they run the SIMOC simulation and analyze the data, they may revise again and re-run the SIMOC simulation. Beginning at this point the students are in a highly productive iterative loop in which they design, test, evaluate, redesign and so on. It is important that the students clearly number and label each new design (iteration).

Evaluating the Solution, Part 1

When the first design is complete, students should evaluate the design. Is the whole design solving the problem? Are the sub-systems realistic and likely to work together to solve the problem. Students may wish to make modifications at this point.

Communicating the Solution, Part 1

Each team will present their design. They should have a drawing or several drawings to show the design. Using the drawings, they should describe the design in as much detail as possible. They should also explain why they think their design will work to solve the problem.

Evaluating the Solution, Part 2

Peer Review: After the team has presented the design, other members of the class can only ask questions of the presenters. This is the essence of the review process. Questions open conversation, while comments – especially critical comments – close discussion. Questions must be civil and productive.
The presenters can choose to answer the questions, or they can defer answering the questions to think about the issues.

Constructing a Prototype Design, Part 2

The presenters may wish to revise the design based on the review. However, they may be ready to proceed to testing their design by running a simulation of the design in the *SIMOC* environment.

Evaluating the Solution, Part 3 Running the SIMOC simulation

Students are now ready to begin the part of the research in which they can get quantitative results of testing their habitat design using the *SIMOC* simulation. They should go to: https://simoc.space/ and follow directions.

Understanding the Science and Engineering Practices and the Crosscutting Concepts

A Framework for K-12 Science Education (see General Resources) published by the National Research Council in 2012 describes a 3-dimensional learning model that includes the intertwining of Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas. This lesson involves students in all of the Science and Engineering Practices and many of the Crosscutting Concepts as they develop an understanding of the core ideas involved in engineering design and ecosystems. (see *SIMOC Standards Alignment* document). It isn't enough, however, that students engage in the Practices and Crosscutting Concepts as they develop a deep understanding of the Core

Ideas. Students must also be cognitively aware of what they are doing and what the Practices and Crosscutting Concepts are. The reflection assignment will engage students in thinking about the Practices and Crosscutting Concepts, about what those Practices and Crosscutting Concepts are, and how the Practices and Crosscutting Concepts relate to doing science. This lesson will assist you in integrating this activity and will suggest resources.

Please Print from SIMOC website and post in classroom**:**

NGSS Practices Poster

NGSS Crosscutting Concepts Poster

Please Read:

Appendix F – Science and Engineering Practices in NGSS

Appendix G – Crosscutting Concepts

Appendix H –The Nature of Science

Activity M: *Reflection on Practices and Crosscutting Concepts* in the Student Guide is designed to help students think about the process they have used to gain an understanding of the phenomenon of a sealed room or habitat.

To help you, information about the Science and Engineering Practices and Crosscutting Concepts has been provided. More information can be found at the Next Generation Science Standards Appendices above.

Science and Engineering Practices

The eight practices of science and engineering that the Framework identifies as essential for all students to learn and describes in detail are listed below:

1. Asking questions (for science) and defining problems (for engineering)
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 (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts

The Framework identifies seven crosscutting concepts that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. The seven crosscutting concepts are as follows:

1. *Patterns*: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. *Cause and effect*: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity*: In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models*: Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter*: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function*: The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. *Stability and change*: For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

4.0 Evaluation/Assessment — Teacher Guide

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

(A) Desigining the Habitat

Earth supplies humans with everything we need to live. But what about when we leave Earth? We currently have research on the International Space Station (ISS) and NASA is preparing to send people to the Moon and Mars in the future. NASA scientists and engineers have found ways to support humans away from Earth. A space suit, a space capsule, and the International Space Station are sealed containers protecting humans in space. These specialized "containers" are designed to provide a habitat that humans need to live in space. But what do humans need to live away from Earth, especially with a three-year round-trip to Mars?

To help you think about this problem, you have been asked to design a habitat that is on Mars. You can bring some initial supplies. After that nothing comes into the habitat and nothing leaves the habitat. For this initial design you can choose how many people you want in your habitat, but there must be at least four. Later you will experiment with different numbers of people. You must design your habitat so that it supplies everything that is needed to keep your team healthy and happy for several years.

There are two additional constraints on the design process.

1. You are designing a habitat to be used on Mars within 25 to 50 years. That means you must research what is know currently known about living in sealed habitats (like the International Space Station).
2. Cost is always a constraint. Although we are not identifying a budget, it is best to keep costs as low as possible. One big cost is the launch of materials from Earth. The current range of costs is $10,000 to $20,000 **per kilogram** and the Curiosity rover cost as much as $2.78 <u>million</u> per kilogram. So, a huge habitat on Mars might be attractive, but it would be very costly. Scientists will probably work for the smallest mass (in kilograms) habitat that will accomplish the mission.

Step 1: How do you stay healthy and happy in a sealed habitat for several years?

- Write a list of as many questions about this problem as you can. This list will help you to design a habitat that meets the criteria of staying healty and happy.
- Share your list with students in your group and listen to the lists they have made.
- Within your group, agree on a list that has the most important question to be answered, the next most important question as number two, and so on.
- Present your group's list to the class, and explain your reasons.
- Discuss the lists as a class and agree on a list of things necessary for humans to live a healthy life.
- Identify the problem or problems the class/groups will attempt to solve to design a safe habitat.

Step 2: The Problem to be Solved

NAME:______________________________

Your final project is to design a research station or parts of a research station that will allow at least four researchers to live on Mars for an extended period of time, explore and do research. This problem breaks down into two areas that require design solutions: researchers must be able to

1) maintain physical health,
2) have a good quality of life.

Ultimately, you want to design an entire habitat. However, you can take this problem apart and create designs to accomplish any part of this problem and then put them together, or you can take on larger parts of the problem. What part of this problem do you want to solve with your design? For example, Do you want to focus on food production in the habitat? Do you want to design a water purification system? Are some of these designs interrelated? Do you want to look at the whole problem?

Talk with the group and decide how you will approach the design problem.

What we are going to design.	What it will do.	Why this is important?

(B) Researching the Problem

NAME:________________________________

After engineers identify the problem, they do research on the problem to understand the requirements.

Working in your group, brainstorm and record questions that you have about the project you have decided to design. Be as specific as you can. These questions will direct your research. The better your questions, the better your research.

Remember to consider how designing a habitat on Mars might be different from designing a habitat on Earth. What do you need to know about Mars?

When you begin your research, always use quality sources. We call these credible (or believable) sources. Use Resource D: *Credible Sources Evaluation* to evaluate your sources.

Example question: What is the temperature on Mars?

(C) What is Mars Really Like?

NAME:______________________________

Do research on conditions on Mars. Some great resources are:

Mars Facts: https://mars.jpl.nasa.gov/allaboutmars/facts/#?c=inspace&s=distance

Mars-ePedia: https://marsed.asu.edu/marsepedia

Find more resources. Use the *Credible Resources Evaluation* to determine whether you can trust the sources.

What did you learn about Mars that is relevant to your design of a Habitat?

Information	Resource

(D) What are sub-systems that can be used in a sealed habitat to support humans?

Do research on some of the sub-systems that can be used to recycle water, recycle oxygen and carbon dioxide, provide food, etc in a closed environment. Some systems are natural, biological systems used on Earth (and in Biosphere 2). Some systems, like space suits, are engineered by humans. There are great resources on the *SIMOC* website. Record your research carefully. The table below is only an outline of your findings. You need to make extensive notes so that you can share and explain to your team. Some great resources are:

- HERA- Human Exploration Research Analog: https://www.nasa.gov/analogs/hera
- University of Arizona Controlled Environment Agriculture Center Prototype Lunar Greenhouse: https://cals.arizona.edu/lunargreenhouse/
- International Space Station Hadfield Videos: https://blogs.scientificamerican.com/psi-vid/top-10-commander-chris-hadfield-videos-from-the-iss/
- https://www.spacestationexplorers.org/news-media/videos/

Find more resources and use the *Credible Resources Evaluation* to determine whether you can trust the sources.

NAME:______________________________

What did you learn that is relevant to your design of a Habitat?

Information	**Resource**

(E) Credible Sources Evaluation

NAME:________________________________

Instructions: Use the following to identify Credible Sources for your research.

What's the difference between a ***primary source*** and a ***secondary source***? For science research, primary sources are original materials not filtered or interpreted by another person or organization. Examples include papers, dissertations, interviews, lab notebooks, study reported in a journal article, and technical reports. A secondary source provides commentary, analysis, discussion, or opinion about the primary source. Examples include review articles, blogs, opinion editorials, newspapers, and news media sources.

URL #1:			
URL #2:			
URL #3:			
Check if Yes ✔			**Criteria for a Credible Source**
Source #1	**Source #2**	**Source #3**	
			1. Is the website an organization [.org], educational institution [.edu], or government [.gov] site? ***If not, see #2, otherwise go to #3.***
			2. Is the website hosted by a ***periodical***, such as a science journal or magazine that publishes science research?
			3. In **Google**, type ***link://*** in front of the home page URL and hit enter. The number in the search result is how many times that page has been linked to as a reference or resource. Is that a big number, such as hundreds of thousands or more? ***If yes, see #4. Otherwise go to #5.***
			4. Investigate the sources (URL's) that have linked to the page. Start at the first link that is not an internal link. Are most of them considered credible sources, such as other .org, .edu, or .gov sites?
			5. Read the "*About us*" section. Is there a list of names for the contributors to the site? ***If yes, see #6, otherwise go to #7.***
			6. Do a search for one of those contributors. Are you able to find information about that person and verify their experience they are advertising on the website? Does their experience match the purpose of the website?
			7. Do links on the page work, meaning they are unbroken?
			8. Is the source a primary source?
			9. Total Score for each resource (total # of checkmarks for each column)

Check if Yes ✔			**Criteria for a *Non*-Credible Source**
Source #1	**Source #2**	**Source #3**	
			1. Is the website a .com or .net site?
			2. Is the website hosted by a blog, satire site (spoof or parody sites that exaggerate truth using humor), or an opinion editorial page?
			3. Does the site use ***loaded language*** or ***biased language***? (These are words that are chosen to influence the reader to react a certain way that is sympathetic to the author's cause using emotion or stereotypes)
			4. Investigate the sources (URL's) that have linked to the page. Are most of them considered non-credible sources?
			5. Is there a list of sponsors or paid for advertisements for the website? ***If yes, see #6, otherwise go to #7.***
			6. Are the sponsors biased toward one opinion, goal, or cause?
			7. Are links broken and/or has the page not been updated recently?
			8. Is the source a secondary source?
			9. Total Score for each resource (total # of checkmarks for each column)

Now, compare the total checkmarks for each URL. For each URL, put a checkmark in either "*It's Credible, It Might be Credible*, or *It's Not Credible*." You can only choose one.

URL	**# of Credible Marks**	**# of non-Credible Marks**	**It's Credible** (2 or fewer checkmarks in the non-Credible Marks column)	**It might be Credible** (checkmarks are somewhat even in both columns)	**It's Not Credible** (5 or more marks in the non-Credible Marks column)
#1					
#2					
#3					

(*These resources were developed by Arizona State University's Mars Education Program, under contract to NASA's Jet Propulsion Laboratory, a division of the California Institute of Technology*)

(F) Brainstorm Possible Design Solutions

Think carefully about the problem you are going to solve and the research you found about possible designs to solve the problem. In this case you have identified many sub-systems (ways to supply fresh water, ways to recycle air, ways to provide food, etc) that are all necessary – and must work together – to make the main system (the habitat) sustainably support human life. In the brainstorm session think about the research you did - which sub-systems seem to work most reliably? How they can work together to create the habitat?

Brainstorm

Brainstorm several different design solutions. Remember, when you brainstorm, don't evaluate or criticize the ideas. Record your possible design solutions – you may even draw them. Listen carefully to everones ideas.

Evaluate

When you have several design solutions, think about each solution critically and discuss each one. Does the design solve the problem? Is it a reasonable design for the conditions of a habitat and research center on Mars? Is it simple or is it very complex? Do you think it will work?

Choose the design that you as a group think is the best solution.

NAME:_______________________________

Habitat Design #: ____________

Describe your habitat as best you can, using labels to point out key features and systems.

Describe your Habitat and how it works?

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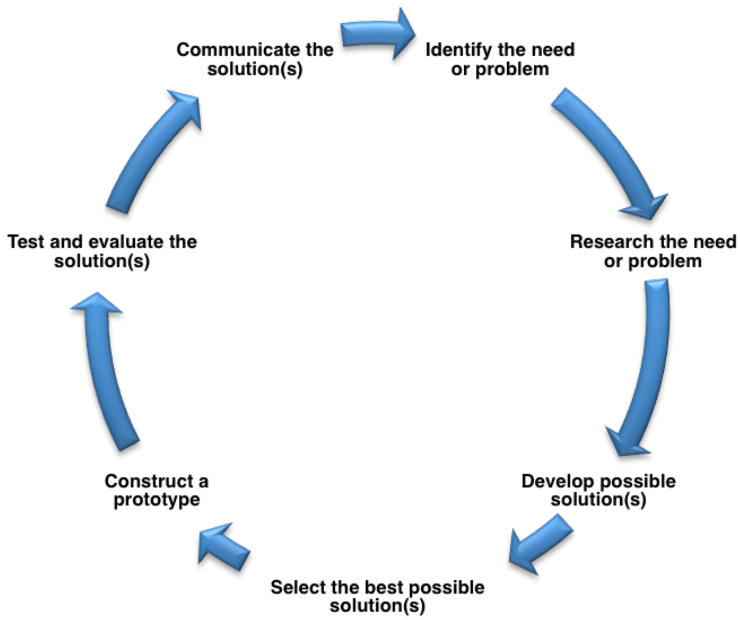
(H) SIMOC Simulation Reflection Sheet

NAME:______________________________

SIMOC Simulation #	What were the starting conditions?	Did it work?	What did not work?	What would you change?

(I) Engineering Design Cycle Defined

This diagram of the engineering cycle is a simplified version of what actually happens in an engineering task. The actual process is much more iterative, often going from later steps in the cycle and circling back to earlier steps as new information is gathered.



Identify the need or problem

- Specify and prioritize requirements and constraints to better define the need or problem

Research the need or problem

- Examine current state of the issue and current solutions
- Explore other options through resources (Ex: Internet, interviews, periodicals, etc.)
- Identify the constraints

Develop possible solution(s)

- Brainstorm possible solutions
- Draw on mathematics and science
- Explain or describe the possible solutions on paper, computer simulation, or 3D model
- Refine the possible solutions

Select the best possible solution(s)

- Determine, using simple analysis, which solution(s) best meet(s) the original requirements

Construct a prototype

- Model the selected solution(s) on paper, computer simulation, or 3D model

Test and evaluate the solution(s)

- Does it work?
- Does it meet the original design constraints?

Communicate the solution(s)

- Make an engineering presentation that includes a discussion of how the solution(s) best meet(s) the needs of the initial problem, opportunity, or need
- Discuss societal impact and tradeoffs of the solution(s)

(J) Engineering Design Cycle Team Summary

Working with your group, discuss and identify where you participated in each part of the Engineering Design Cycle. Review the *(B) Daily Reflection Sheets* for help with this.

Write the event, problem, need, solution, test, etc. your team participated in next to the appropriate section of the cycle. Include arrows between steps if your team needed to go back (iteration) during the planning to test a new solution. There should be at least one example next to each step in the cycle

(K) About the Engineering Cycle

NAME:______________________________

What did you try that didn't work out? How many times did something like this happen?	What did you do when things didn't work out like you expected?

If given enough time, what would your next step look like?

(L) About your Thinking

NAME:___________________________________

What were some of the struggles you and your team went through during the project?	What was surprising to you about the engineering cycle?

What do you think you have learned from this process you didn't know before?

(M) Reflection on Practices and Crosscutting Concepts

When scientists study phenomena to better understand how the natural world works or when engineers design solutions to a problem, they engage in certain processes called practices. These practices are, essentially, how science or engineering is done. These practices are:

1. Asking questions (for science) and defining problems (for engineering)
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 (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

In your group, reflect carefully on the activities you have just completed and answer the following questions using the table on the next page.

a. What Science and/or Engineering Practice did you do?
b. When? During which activities?
c. Explain your reasoning for you claim.

NAME:__________________________________

Practice	When?	What is your reasoning?
Asking questions and defining problems		
Developing and using models		
Planning and carrying out investigations		
Analyzing and interpreting data		
Using mathematics and computational thinking		
Constructing explanations or designing solutions		
Engaging in argument from evidence		
Obtaining, evaluating, and communicating information		

When scientists study phenomena to better understand how the natural world works or when engineers design solutions to a problem, they use concpts that are important in all science and engineering problems. These crosscutting concepts provide insight into new problems. These Crosscutting Concepts are:

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

In your group, reflect carefully on the activities you have just completed and answer the following questions using the table on the next page.

d. What Crosscutting Concepts were important to what you did?
e. When? During which activities?
f. Explain your reasoning for you claim.

NAME:________________________________

Crosscutting Concept	When?	What is your reasoning?
Patterns		
Cause and effect: Mechanism and explanation		
Scale, proportion, and quantity		
Systems and system models		
Energy and matter: Flows, cycles, and conservation		
Structure and function		
Stability and change		

(N) Design Rubrics

	Expert	Proficient	Intermediate	Novice
Engineering Design Cycle	Demonstrates multiple iterations (loops) in the cycle using concrete examples from reflection sheet. Each example is appropriately placed and loops back to the correct step of the cycle.	Demonstrates multiple iterations (loops) in the cycle using concrete examples from reflection sheet. Most examples are appropriately placed and loop back to the correct step of the cycle.	Demonstrates a couple of iterations (loops) in the cycle using concrete examples from reflection sheet. Examples are appropriately placed and loop back to the correct step of the cycle.	Demonstrates a one correct iteration (loops) in the cycle, possibly using an example from the reflection sheet.
Prototype Description	Drawing clearly marks key features of the prototype critical to the function and meets the needs of the problem. Description fully discusses all components of the prototypes and how they address the needs of the problem.	Drawing clearly marks many key features of the prototype critical to the function and meets most of the needs of the problem. Description discusses components of the prototypes and how they address the needs of the problem.	Drawing marks a couple of key features of the prototype critical to the function and meets a couple of the needs of the problem. Description discusses components of the prototypes.	Drawing marks a key feature or two. Description and design reflect the personal interests of the group.
Designing Reflection	Reflection fully acknowledges the need to fail and make multiple iterations, yet is still forward thinking to the next steps of the design.	Reflection acknowledges the need to fail and make iterations, yet is still forward thinking to the next steps of the design.	Reflection acknowledges the need to make iterations and there are next steps but these are undefined.	Reflection discusses the success of the first or second prototype and points to this as the final product.
Thinking Reflection	Reflection fully acknowledges the struggles in the process and provides concrete examples of learning as a result of these struggles.	Reflection acknowledges the struggles in the process and provides a concrete example of learning as a result of these struggles.	Reflection acknowledges the struggles in the process and makes an unspecified claim about learning as a result of these struggles.	Reflection discusses the success and complete understanding of the process from day 1.

Assessment Rubric: Complete System

Guide Questions: What are the important characteristics of a successful ecosystem? What modifications are necessary for a successful ecosystem in a closed system on Mars?

Task to be Assessed: Students will design an ecosystem in a sealed container and explain why it should be successful on Mars.

Knowledge Areas

	Exemplary	Proficient	Developing	Novice
Understanding of characteristics of successful ecosystems on Earth	Ecosystem has all of the elements necessary to provide a flow of energy and recycling of materials. Each organism is able to meet its needs sustainably. Presentation clearly and accurately describes energy pyramid, food pyramid, recycling of materials, food webs, and interactions of biotic and abiotic factors in the ecosystem. Attempt is made to quantitatively determine and describe characteristics.	Organisms are chosen and abiotic factors provided so that organisms can meet requirements for life and material is recycled. Presentation describes interactions of biotic and abiotic factors. Presentation describes why organisms should survive for extended period of time.	Organisms are chosen because one organism eats another. Abiotic factors are provided based on students' experience providing care for plants and animals. Presentation describes what is in the system.	Organisms for ecosystem are chosen because the student likes or needs them. The system would require additions of materials.
Understanding of current technology	Current technology appropriately supplements ecosystem and is appropriate for Mars. Presentation clearly and accurately describes the technology used and its role in supporting the ecosystem. Attempt is made to quantitatively determine and describe characteristics.	Technology appropriately supplements ecosystem and is appropriate for Mars. Presentation describes how the technology supports the ecosystem.	Student uses technology described for the International Space Station. Presentation describes what technology is used.	Student uses technology familiar in the home or school.

SIMOC

Assessment Rubric: Complete System (continued)				
Knowledge Areas (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of resources and challenges on Mars	Design and presentation demonstrate a clear and accurate understanding of the resources and challenges for a successful ecosystem on Mars. Choice of location is explained. Attempt is made to quantify resources and challenges in comparison with Earth.	Design uses local resources and technology to solve the challenges to maintaining a successful ecosystem on Mars. Presentation describes how challenges are met.	Design focuses on some of the challenges of creating an ecosystem on Mars. Presentation describes the challenges.	Design is based on the assumption that Mars is very similar to Earth, but hotter, and the resources will be the same. OR Design includes constant re-supply of materials.
Integration of Knowledge	Design takes into account all knowledge areas. Presentation demonstrates a clear and accurate understanding of the inter-relatedness of all knowledge areas.	Design takes into account all knowledge areas.	Design takes into account more than one knowledge area, and one dominates.	Design tends to focus on one knowledge area, assuming the Moon or Mars will not be different from Earth.
Construction of Design Model	Model clearly and accurately represents all of the elements of the design. Appropriate materials were chosen and used creatively. Model was attractive and informative.	Model effectively represents all of the elements of the design. Appropriate materials were chosen.		Model focuses on a couple of the aspects of the design. Materials were chosen for attractiveness.

Assessment Rubric : Complete System (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Effectiveness of Presentation	Presentation was clear, accurate, well organized, and interesting. Visual aids were accurate, attractive and important to the presentation. Audience could clearly understand the design of the ecosystem in a sealed container and reasons to expect success at chosen location.	Presentation was clear and organized. Visual aids were used to highlight the presentation. Audience could understand the design of the ecosystem in a sealed container.		Student presented ideas as they came to mind.

Assessment Rubric **Nutrition** Guide Questions: How can humans maintain proper nutrition and exercise? What modifications are necessary for extended space missions? Task to be assessed: Students will design a healthy diet and exercise plan for an extended stay on the Moon or Mars and explain why it should be appropriate on the Moon or Mars.				
Knowledge Areas				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of characteristics of a healthy diet and exercise plan on Earth	Plan and presentation demonstrate a clear and accurate understanding of requirements for proper nutrition and exercise. Plan is very detailed and quantitative and reflects the needs of a variety of people.	Diet plan requires proper amounts of different kinds of food that are appropriate for good nutrition. Exercise plan is appropriate to maintain health. Presentation reflects a good understanding of how to use nutrition and exercise guides.	Plan and presentation reflect an understanding that good nutrition includes eating a variety of foods and eating less sugar and fats, and that exercise is important	Plan and presentation reflect the likes and experiences of the student.
Understanding of current diet and exercise adaptations for space missions	Plan and presentation demonstrate a clear and accurate understanding of current adaptations for space missions. Differences between requirements for Earth and the Moon or Mars are clearly explained. Adaptations are appropriately and creatively used to support missions to Mars.	Plan is appropriate to a mission to Mars. Plan uses what has been learned on the ISS and makes appropriate modifications for the Moon or Mars.	Plan is essentially the same as a diet and exercise plan on the International Space Station.	Plan for space missions is essentially the same as for Earth.

Assessment Rubric Nutrition (continued)				
Knowledge Areas (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of resources and challenges on Mars	Plan and presentation demonstrate a clear and accurate understanding of the resources and challenges on Mars. Attempt is made to quantify resources and challenges in comparison with Earth.	Plan uses technology and local resources to solve the challenges of providing a nutritious diet and healthy exercise on Mars. Presentation describes how challenges are met.	Plan focuses on some of the challenges of a healthy plan on the Moon or Mars. Presentation describes the challenges.	Plan is based on the assumption that Mars is very similar to Earth, but hotter, and the resources will be the same. OR Design includes constant re-supply of food.
Integration of Knowledge	Design takes into account all knowledge areas. Presentation demonstrates a clear and accurate understanding of the inter-relatedness of all knowledge areas.	Design takes into account all knowledge areas.	Design takes into account more than one knowledge area, and one dominates.	Design tends to focus on one knowledge area, assuming the Moon or Mars will not be different from Earth.
Effectiveness of Presentation	Presentation was clear, accurate, well organized, and interesting. Visual aids were accurate, attractive and important to the presentation. Audience could clearly understand the plan and reasons to expect success at chosen location.	Presentation was clear and organized. Visual aids were used to highlight the presentation. Audience could understand the plan.		Student presented ideas as they came to mind.

Assessment Rubric

Air and Water

Guide Questions: How can humans maintain sufficient clean water and breathable air? What modifications are necessary for an extended space missions?

Task to be assessed: Students will design a system to maintain clean water and breathable air in a habitat on the Moon or Mars and explain why it should be successful.

Knowledge Areas

	Exemplary	Proficient	Developing	Novice
Understanding of how clean air and water are maintained naturally within Earth's ecosystems	Design and presentation demonstrate a clear and accurate understanding of how to maintain clean water and breathable air on Earth. Presentation describes differences and similarities between designed system and Earth.	Design makes effective use of knowledge of how air and water are recycled on Earth. Presentation describes how design is similar to Earth system.	Design focuses on technological methods for cleaning water and air, such as water treatment plants.	Student believes that clean air and water are always available on Earth. OR Student believes that once air or water is used it disappears or is discarded.
Understanding of current technology	Design and presentation demonstrate a clear and accurate understanding of current technology for recycling wastes and regenerating oxygen and pure water. Connection of technology to human requirements is clearly made. The role of technology is clearly explained. Technology is used appropriately.	Design makes effective use of understanding of current technology for recycling wastes and regenerating oxygen and pure water. The technology is well described.	Design focuses on removing harmful wastes from air and water.	Design depends on re-supply of air and water from Earth. OR Any technology that is used is modeled after sewage treatment plants.

Assessment Rubric

Air and Water (continued)

Knowledge Areas (continued)

	Exemplary	Proficient	Developing	Novice
Understanding of resources and challenges on the Moon or Mars	Design and presentation demonstrate a clear and accurate understanding of the resources and challenges to recycling wastes and regenerating oxygen and pure water on Mars. Choice of location is explained. Attempt is made to quantify resources and challenges in comparison with Earth.	Design uses local resources and technology to solve the challenges to recycling wastes and regenerating oxygen and pure water on Mars. Presentation describes how challenges are met.	Design is modeled after systems on the ISS or sewage treatment on Earth. Presentation describes challenges of removing harmful wastes from air and water on Mars.	Design is based on the assumption that Mars is very similar to Earth, but hotter, and the resources will be the same. OR Design includes constant re-supply of oxygen and water.
Integration of Knowledge	Design takes into account all knowledge areas. Presentation demonstrates a clear and accurate understanding of the inter-relatedness of all knowledge areas.	Design takes into account all knowledge areas.	Design takes into account more than one knowledge area, and one dominates.	Design tends to focus on one knowledge area, assuming the Moon or Mars will not be different from Earth.
Construction of Design Model	Model clearly and accurately represents all of the elements of the design. Appropriate materials were chosen and used creatively. Model was attractive and informative.	Model effectively represents all of the elements of the design. Appropriate materials were chosen.		Model focuses on a couple of the aspects of the design. Materials were chosen for attractiveness.

Assessment Rubric Air and Water (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Effectiveness of Presentation	Presentation was clear, accurate, well organized, and interesting. Visual aids were accurate, attractive and important to the presentation. Audience could clearly understand the design of the system to recycle wastes and regenerate oxygen and pure water and reasons to expect success at chosen location.	Presentation was clear and organized. Visual aids were used to highlight the presentation. Audience could understand the design of the system to recycle wastes and regenerate oxygen and pure water.		Student presented ideas as they came to mind.

Assessment Rubric

Waste

Guide Questions: How can matter be recycled effectively? What modifications are necessary for extended space missions?

Task to be assessed: Students will design a system to recycle matter in a habitat on the Moon or Mars and explain why it should be successful.

Knowledge Areas

	Exemplary	Proficient	Developing	Novice
Understanding of how matter is recycled on Earth	Design and presentation demonstrate a clear and accurate understanding of how biological and manufactured matter are recycled on Earth. Attempt is made to present recycling quantitatively. New materials are proposed for manufactured items to make them more easily recycled.	Design allows for nearly complete recycling of all biological and manufactured matter. Presentation demonstrates an understanding of how matter is recycled on Earth and how their design differs.	Design and presentation include biological recycling of some materials. Other materials, especially manufactured items, are discarded.	Design involves using and discarding materials by separating materials by type (e.g., aluminum, plastic, etc).
Understanding of current technology	Current technology appropriately supplements ecosystem and is appropriate for the Moon or Mars. Presentation clearly and accurately describes the technology used and its role in supporting the ecosystem. Attempt is made to quantitatively determine and describe characteristics.	Technology appropriately supplements ecosystem and is appropriate for the Moon or Mars. Presentation describes how the technology supports the ecosystem.	Student uses technology described for the International Space Station. Presentation describes what technology is used.	Student uses technology familiar in the home or school.

Assessment Rubric **Waste** (continued)				
Know**ledge Areas** (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of resources and challenges on Mars	Design and presentation demonstrate a clear and accurate understanding of the resources and challenges to recycling material on Mars. Choice of location is explained. Attempt is made to quantify resources and challenges in comparison with Earth.	Design uses local resources and technology to solve the challenges to recycling material on Mars. Presentation describes how challenges are met.	Design is modeled after systems on the ISS or recycling of manufactured material on Earth. Presentation describes challenges of recycling on the Moon or Mars.	Design is based on the assumption that Mars is very similar to Earth, but hotter, and the resources will be the same. OR Design includes constant re-supply.
Integration of knowledge	Design takes into account all knowledge areas. Presentation demonstrates a clear and accurate understanding of the inter-relatedness of all knowledge areas.	Design takes into account all knowledge areas.	Design takes into account more than one knowledge area, and one dominates.	Design tends to focus on one knowledge area, assuming Mars will not be different from Earth.
Construction of Design Model	Model clearly and accurately represents all of the elements of the design. Appropriate materials were chosen and used creatively. Model was attractive and informative.	Model effectively represents all of the elements of the design. Appropriate materials were chosen.		Model focuses on a couple of the aspects of the design. Materials were chosen for attractiveness.

Assessment Rubric **Waste** (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Effectiveness of Presentation	Presentation was clear, accurate, well organized, and interesting. Visual aids were accurate, attractive and important to the presentation. Audience could clearly understand the design of the system to recycle wastes and regenerate oxygen and pure water and reasons to expect success at chosen location.	Presentation was clear and organized. Visual aids were used to highlight the presentation. Audience could understand the design of the system to recycle wastes and regenerate oxygen and pure water.		Student presented ideas as they came to mind.

Assessment Rubric **Final SIMOC Project** Essential Question: What kinds of habitats can be designed to support extended human activity in space or on Mars? Task to be assessed: Design a research habitat that will allow researchers to live on Mars for an extended period of time. Researchers must be able to maintain physical health and a good quality of life.				
Knowledge Areas				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of characteristics of successful ecosystems	Habitat ecosystem has all of the elements necessary to provide a flow of energy and recycling of materials. Each organism is able to meet its needs sustainably. Presentation clearly and accurately describes energy pyramid, food pyramid, recycling of materials, food webs, and interactions of biotic and abiotic factors in the ecosystem. Attempt is made to quantitatively determine and describe characteristics.	Organisms in habitat are chosen and abiotic factors provided so that organisms can meet requirements for life and material is recycled. Presentation describes interactions of biotic and abiotic factors. Presentation describes why organisms should survive for extended period of time.	Organisms in habitat are chosen because one organism eats another. Abiotic factors are provided based on students' experience providing care for plants and animals. Presentation describes what is in the system.	Organisms for habitat ecosystem are chosen because the student likes or needs them. The system would require additions of materials.
Understanding of characteristics of a healthy diet and exercise plan	Plan and presentation demonstrate a clear and accurate understanding of requirements for proper nutrition and exercise. Plan is very detailed and quantitative and reflects the needs of a variety of people.	Diet plan requires proper amounts of different kinds of food that are appropriate for good nutrition. Exercise plan is appropriate to maintain health. Presentation reflects a good understanding of how to use nutrition and exercise guides.	Plan and presentation reflect an understanding that good nutrition includes eating a variety of foods and eating less sugar and fats, and that exercise is important	Plan and presentation reflect the likes and experiences of the student.

Assessment Rubric **Final SIMOC Project** (continued)				
Knowledge Areas (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of how clean air and water are maintained naturally within Earth's ecosystems	Design and presentation demonstrate a clear and accurate understanding of how to maintain clean water and breathable air on Earth. Presentation describes differences and similarities between habitat system and Earth.	Design makes effective use of knowledge of how air and water are recycled on Earth. Presentation describes how habitat is similar to Earth system.	Design focuses on technological methods for cleaning water and air, such as water treatment plants.	Student believes that clean air and water are always available on Earth. OR Student believes that once air or water is used it disappears or is discarded.
Understanding of how matter is recycled	Habitat design and presentation demonstrate a clear and accurate understanding of how biological and manufactured matter are recycled on Earth and how the habitat is different. Attempt is made to present recycling quantitatively. New materials are proposed for manufactured items to make them more easily recycled.	Design allows for nearly complete recycling of all biological and manufactured matter. Presentation demonstrates an understanding of how matter is recycled on Earth and how their habitat design differs.	Design and presentation include biological recycling of some materials. Other materials, especially manufactured items, are discarded.	Design involves using and discarding materials by separating materials by type (e.g., aluminum, plastic, etc).
Understanding of current technology to maintain a healthy habitat for humans on Mars	Current technology appropriately supplements ecosystem and is appropriate for location. Presentation clearly and accurately describes technology used and its role. Attempt is made to quantitatively determine and describe characteristics.	Technology appropriately supplements ecosystem and is appropriate for the Moon or Mars. Presentation describes how the technology supports the ecosystem.	Student uses technology described for the International Space Station. Presentation describes what technology is used.	Student uses technology familiar in the home or school.

Assessment Rubric Final SIMOC Project (continued)				
Knowledge Areas (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Understanding of resources and challenges on Mars	Design and presentation demonstrate a clear and accurate understanding of the resources and challenges for a successful habitat on Mars. Choice of location is explained. Attempt is made to quantify resources and challenges in comparison with Earth.	Design uses local resources and technology to solve the challenges to maintaining a successful habitat on Mars. Presentation describes how challenges are met.	Design focuses on several of the challenges of a successful habitat on Mars. Presentation describes the challenges.	Design assumes that Mars is very similar to Earth, but hotter, and the resources will be the same. OR Design includes constant re-supply of materials.
Integration of knowledge	Design considers all knowledge areas. Presentation demonstrates a clear and accurate understanding of the inter-relatedness of all knowledge areas.	Design considers all knowledge areas.	Design considers more than one knowledge area, and one dominates.	Design tends to focus on one knowledge area, assuming Mars will not be different from Earth.
Construction of Design Model	Model clearly and accurately represents all of the elements of the design. Appropriate materials were chosen and used creatively. Model was attractive and informative.	Model effectively represents all of the elements of the design. Appropriate materials were chosen.		Model focuses on a couple of the aspects of the design. Materials were chosen for attractiveness.

Assessment Rubric Final SIMOC Project (continued)				
	Exemplary	**Proficient**	**Developing**	**Novice**
Effectiveness of Presentation	Presentation was clear, accurate, well organized, and interesting. Visual aids were accurate, attractive and important to the presentation. Audience could clearly understand the design of the system to recycle wastes and regenerate oxygen and pure water and reasons to expect success at chosen location.	Presentation was clear and organized. Visual aids were used to highlight the presentation. Audience could understand the design of the system to recycle wastes and regenerate oxygen and pure water.		Student presented ideas as they came to mind.