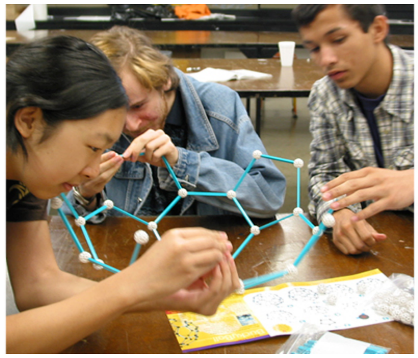
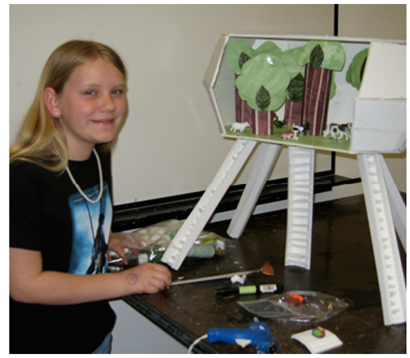
Follow Your Curiosity: A 2012 NASA Summer of Innovation Collection

Lesson 13

Constructing Your Sustainable Communities on Mars

Grades: 6-8 Prep Time: 15 Minutes Lesson Time: 2-3 Hours





WHAT STUDENTS DO: Construct a Model

Curiosity and creativity go hand-in-hand. In building a model of a sustainable community for the extreme environment on Mars, where did students' curiosity lead? What did it enable them to create? Collaborating is a key component of 21st Century Skills. In this activity, students work together to build a representational model of their community (no-tech and high-tech options). In this collection, this lesson provides students with the chance to make their designs come to life in a scale model, drawings, or other concrete representations. It originates from the Imagine Mars Project, co-sponsored by NASA and the National Endowment for the Arts: http://imaginemars.jpl.nasa.gov

NRC CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVE
HOW DO ENGINEERS SOLVE PROBLEMS? *NRC Core Question: ETS1: Engineering Design*	*Students will be able*
What Is a Design for? What are the criteria and constraints of a successful solution? *NRC ETS1.A: Defining & Delimiting an Engineering Problem*	**IO1: to construct** a model according to criteria
What Is the Process for Developing Potential Design Solutions? *NRC ETS1.B: Developing Possible Solutions*	

1.0 About This Activity

This activity is part of the Imagine Mars Project, co-sponsored by NASA and the National Endowment for the Arts (NEA). The Imagine Mars Project is a hands-on, STEM-based project that asks students to work with NASA scientists and engineers to imagine and to design a community on Mars using science and technology, then express their ideas through the arts and humanities, integrating 21st Century skills. The Imagine Mars Project enables students to explore their own community and decide which arts-related, scientific, technological, and cultural elements will be important on Mars. Then, they develop their concepts relating to a future Mars community from an interdisciplinary perspective of the arts, sciences, and technology. imaginemars.jpl.nasa.gov

The Imagine Mars lessons leverage *A Taxonomy for Learning, Teaching, and Assessing* by Anderson and Krathwohl (2001) (See *Section 4* and *Teacher Guide* at the end of this document). This taxonomy provides a framework to help organize and align learning objectives, activities, and assessments. The taxonomy has two dimensions. The first dimension, cognitive process, provides categories for classifying lesson objectives along a continuum, at increasingly higher levels of thinking; these verbs allow educators to align their instructional objectives and assessments of learning outcomes to an appropriate level in the framework in order to build and support student cognitive processes. The second dimension, knowledge, allows educators to place objectives along a scale from concrete to abstract. By employing Anderson and Krathwohl's (2001) taxonomy, educators can better understand the construction of instructional objectives and learning outcomes in terms of the types of student knowledge and cognitive processes they intend to support. All activities provide a mapping to this taxonomy in the Teacher Guide (at the end of this lesson), which carries additional educator resources. Combined with the aforementioned taxonomy, the lesson design also draws upon Miller, Linn, and Gronlund's (2009) methods for (a) constructing a general, overarching, instructional objective with specific, supporting, and measurable learning outcomes that help assure the instructional objective is met, and (b) appropriately assessing student performance in the intended learning-outcome areas through rubrics and other measures. Construction of rubrics also draws upon Lanz's (2004) guidance, designed to measure science achievement.

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

2.0 Materials

Required Materials

Please supply:

Low-tech:

Materials for hand-crafted models.

- Materials from recycle bin for making models
- Craft supplies for making models (tape, scissors, markers, foam core, hot glue, etc.)
- One "land plot" per student group (note cards, paper, cardboard etc.)
- One notecard labeled with the name of each team for each student (e.g., if you have five teams, each student should receive five notecards)

OR

Self-determined materials. See section 6.

- Some projects may wish to integrate other arts and humanities or other disciplines, depending on their focus. Some past projects have created a government for Mars (civics/social studies) using knowledge of the Martian environment and its challenges. Others have created plays, operas, dances, and concerts that reflect their understanding of the way in which Mars is different, and the meaning for students.

High-tech:

- For enhanced computer and 21st Century Skills, many projects use presentation software or free computer-based design programs such Google Sketch Up to create their communities. Other projects design and make products or systems needed by their community using such products as Simple Machines, Pico Crickets etc. If this option is selected, note that more time may be needed to train students in procedural or other skills needed to use the technology selected.

From Prior Lessons

(1) Students' Draft Community Plans – 1 per student
from IMAGINE (Lesson 12 in this collection)
(2) Student Community Evaluation Checklist – 1 per team
From IMAGINE (Lesson 12 in this collection)

Please Print:

From Student Resources

(A) Mars Quick Facts – 1 per student
(B) Community Quality Assessment – 1 per team
(C) Scenario Cards – 1 per team

Optional Materials

From Teacher Resources

(D) "Share" Assessment Rubrics
(E) Alignment of Instructional Objective(s) and Learning Outcome(s) with Knowledge and Cognitive Process Types

3.0 Vocabulary

Community planning	the process of thinking systematically through neighborhood-based problems and situations (The Enterprise Foundation, 1999)
Constraints	restricting or limiting circumstances
Design Criteria	the standards that are used to judge a proposal
Explanations	logical descriptions applying scientific and technological information
Evaluate	check the scientific validity or soundness
Investigation	an exploration of a topic or question to gain information
Models	a simulation that helps explain natural and man-made systems and shows possible flaws
Reasoning	reaching conclusions based on facts

4.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

Instructional objectives, standards, and learning outcomes are aligned with the National Research Council's *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, which serves as a basis for upcoming "Next-generation Science Standards." Current National Science Education Standards (NSES) and other relevant standards are listed for now, but will be updated when the new standards are available.

The following chart provides details on alignment among instructional objectives, learning outcomes, and educational standards.

- Your general **instructional objective(s) (IO)** for this lesson align with the NRC Framework and education standards.
- You will know that you have achieved these instructional objectives if students demonstrate the related, specific, and measurable **learning outcome(s) (LO)**.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics** (Appendix B).

Details of alignment and the way in which instructional objectives and learning outcomes were derived through an adaptation of Anderson and Krathwohl's (2001) taxonomy can be found for reference in Appendix B, along with rubrics and other resources for educators.

ETS1A:

HOW DO ENGINEERS SOLVE PROBLEMS? *NRC Core Question: ETS1: Engineering Design* **What Is a Design for? What are the criteria and constraints of a successful solution?** *NRC Component Question ETS1.A: Defining & Delimiting an Engineering Problem*			
Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*	
IO1: **to construct** a model according to criteria	**LO1a.** **to build** an initial model of a sustainable community that meets criteria and constraints	**NSES (E): SCIENCE & TECHNOLOGY:** **Abilities of Technological Design** **Grades 5-8:** E1b: Design a Solution or a Product	***Rubrics in Teacher Guide***

ETS1B:

HOW DO ENGINEERS SOLVE PROBLEMS? *NRC Core Question: ETS1: Engineering Design* **What Is the Process for Developing Potential Design Solutions?** *NRC ETS1.B: Developing Possible Solutions*			
Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*	
IO1: **to construct** a model according to criteria	**LO1b.** **to create** quality measures aligned with criteria **LO1c.** **to modify** a model of a sustainable community to meet a challenge **LO1d.** **to evaluate** a model based on criteria, constraints	**NSES (E): SCIENCE & TECHNOLOGY:** **Abilities of Technological Design** **Grades 5-8:** E1d: Evaluate Completed Technological Designs or Products	***Rubrics in Teacher Guide***

5.0 Procedure

PREPARATION (~15 minutes)

Provide or ask students to bring in found objects

STEP 1: ENGAGE (~10 minutes)
Envision the Environment.

A. Ask students to close their eyes and to imagine what the community that they envisioned would look like on Mars, based on what they know about how Mars is different from Earth. Ask questions such as the following:

a. What sounds would be there naturally?

b. What sounds would the technologies produce?

c. What would the air in the sky look like? Inside your habitat, would the air be humid or dry?

d. What colors would occur naturally?

e. What colors would the human-made products be?

B. Allow students to share their thoughts for each question. This step provides an opportunity to assess individual students' understanding and remaining misconceptions from prior stages in learning about Mars and the way in which its environment would be different from Earth's.

STEP 2: EXPLORE (~60 minutes)
Construct models.

A. Explain to students that they will be using "found objects" to create a 3D model of their communities. (Or adjust explanation if creating q product other than a hand-crafted community model (see Section 2.0) if using a high-tech option (e.g., Google Sketch Up, Simple Machines, Pico Crickets), more time in pre-training students on procedural skills in using the technology may be needed.

B. Review the criteria developed in the IMAGINE session or use the following criteria:

C. Give students a copy of *(A) Mars Quick Facts* and remind students that each environmental constraint must be addressed in the community model.

D. Show students the found objects they might use.

E. Give students their land plots (notecards, piece of paper, or cardboard)

Teacher Tip: You can control the size of their creations by giving students a specific land plot. For smaller communities, use note cards; for larger communities, use big pieces of cardboard.

F. Give students time to create their communities collaboratively.

STEP 3: EXPLAIN (~20 minutes)
Peer evaluation of quality.

A. Tell students that each team will work together to describe their model in terms of meeting environmental and sociocultural requirements. They should use the criteria from the IMAGINE lesson.

B. Give students *(B) Community Quality Assessment*, 1 per team. Direct students to fill in the criteria; they should refer to (F) Community Evaluation Checklist from the IMAGINE lesson. Review the directions on the sheet.

C. Students should work with one other group. Each group should explain how the different components meet requirements. As one group is presenting, the other should rate the quality of each element using the scale on *(B) Community Quality Assessment.*

Teacher Tip: Some research indicates that the ability to critique other students' projects can be a sign not just of knowledge acquisition, but of transfer to a new circumstance. This activity can also be used as a diagnostic for how well students are synthesizing and applying knowledge.

Teacher Tip: You may want to set a timer for 7 minutes for explanations and 2 or 3 minutes to review feedback.

D. At the end, allow students time to make changes and additions based on the feedback.

STEP 4: ELABORATE (~10 minutes)
Meet challenge.

A. Tell students that each community group will receive a *(C) Scenario Card*. The card presents one challenge to the community on Mars. If a group does not pass the challenge, that group will need to make changes to their community.

Teacher Tip: If you notice that a specific group has an incomplete or incorrect understanding of one of the constraints (e.g., climate, gravity, atmosphere etc.), you can target a specific card (including one you create yourself) for them to consider.

B. Give each group a card and have one group member read it aloud. Ask the group to explain how they propose passing the challenge. Allow other groups to share ideas about how to pass the challenge.

C. Repeat the process until each group has undergone one challenge.

D. Give students time to make improvements to their communities.

STEP 5: EVALUATE (~30 minutes)

Evaluate Community.

A. Using *(B) Community Quality Assessment*, students should evaluate the quality of their community designs.

B. Explain that they will be using the final column to evaluate their communities.

C. Clarify that this is a formative assessment tool, and groups will have the opportunity to fix any areas of weakness and improve areas of strengths. If they are missing in one area, groups have time to add to their models.

D. Explain to students that, in the next lesson, they will share their final products.

Curiosity Connection Tip: For making a connection to NASA's Mars Rover "Curiosity," please show your students additional video and slideshow resources at:

http://mars.jpl.nasa.gov/participate/marsforeducators/soi/

6.0 Extensions

Arts, Humanities and Design Inclusion Options:

Architecture: Create designs that explore the architectural potential of structures on Mars, where gravitational, atmospheric, and many other environmental factors are very different than those on Earth.

Dance: Choreograph a dance piece that explores/illustrates the difference of physical movement in reduced gravity (*1/3 of Earth's gravity*).

Role Play: Pretend you are a newscaster for the evening news and create the news stories for Weather, Headline News, Sports, Entertainment, etc. Don't forget the TV commercials! Students can also record their performance and edit their work into a short video news segment for their final presentations.

Product Design/Invention: Create inventions that help your Mars community thrive. For example, create an invention to access underground water ice, to purify water, or to conserve water in their community; or, to invent a sport or way to play that maximizes the use of reduced gravity.

Social Studies: Research the history of the Julian Calendar and learn about the origins of the names of each of our Earth months. Since the year on Mars is about twice as long (687 Earth days), students can create new names for these months and explain why they chose these new names.

Differentiation Tip: For older or more advanced students, look at the varying lengths of seasons on Mars due to its elliptical orbit and mathematically come up with "months" of different lengths than those on Earth.

Storytelling. Make a comic book layout, write a story, make a journal, paint a mural, or create a musical score that tells the story of a specific challenge you faced during your first year on Mars.

Technology Options: Use architectural modeling software to visualize community and/or product/invention designs. One available free resource that some past projects have used is Google SketchUp (http://sketchup.google.com/).

Introduce students to entry-level programming and technological design by asking them to bring their product designs or inventions to life with movement. Some past projects have used the Pico Crickets invention kit (http://www.picocricket.com).

7.0 Evaluation/Assessment

In the Teacher Guide, use the "Create" Rubric (D) as a formative and summative assessment using 21st Century Skills, NRC Framework Endpoints, and National Science Education Standards.

8.0 References

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

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

Lantz, H.B. (2004). *Rubrics for Assessing Student Achievement in Science Grades K-12.* Thousand Oaks: Corwin Press.

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