STAR net

Hands-on

Tested & Approved STEM Activities

Build A Space Colony

Activity Guide

STAR net
Science-Technology Activities & Resources For Libraries

A product of the Science-Technology Activities and Resources for Libraries (STAR_Net) program.
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Build A Space Colony

Activity Time

This activity is flexible and open-ended; it can be done in 30 minutes but children can take up to 2 hours if desired.

Intended Audience

Families or other mixed-age groups, including children as young as 5 years old *with assistance from an older child, teen, or adult*
School-aged children
Tweens
Teens

Type of Program

- ☑ **Facilitated hands-on experience**
- ☑ **Station, presented in combination with related activities**
- ☑ **Passive program (if instructions are provided at the start of the course)**
- ☐ Demonstration by facilitator

Overview

Participants design technology to provide air to breathe, plentiful food, shielding from ultraviolet light, power, and more for space explorers. They construct a model of their technology from craft materials and incorporate it with other teams' designs into a model space colony.

What's The Point?

- **Humans — like all living things — have specific requirements to live.**
- **The Moon, Mars, asteroids, and other planetary bodies are harsh environments for humans: temperatures are extreme, there are high levels of radiation, there is little or no atmosphere, and there are no sources of food or water.**
- **Providing and maintaining the conditions, resources, and systems required to support human life in space is a complex, challenging task.**
- **Makers and engineers — like the participants — have creative ideas for building the colonies that astronauts need to explore our solar system.**

Materials

Facility needs:

- ☐ 5 sets of tables and chairs
- ☐ 1 large table or other surface to display the colony (short- or long-term)

For the facilitator:

- ☐ Facilitator Background Information (below)
- ☐ Optional: a writing surface where the groups may sketch and write, such as:
  - ☐ 1 white board **AND** ☐ 4–8 dry-erase or other appropriate low- or no-odor markers
  - **OR**
  - ☐ 2–4 (~36″ × 48″) pieces of butcher paper, posted on the wall or used to cover the tables
  - **OR**
  - ☐ 4–8 crayons **OR** ☐ 5 or more sheets of poster paper

For each group of 10 to 15 participants:

- ☐ 1 (8½″ × 11″) *Be Creative…Be an Engineer!* poster (for tweens, teens, and adult helpers) (last page of guide)
- ☐ Colored pencils or markers
- ☐ Rulers
- ☐ Tape
- ☐ Clean, repurposed materials, such as:
  - ☐ 3-4 large pieces of cardboard
  - ☐ 3-4 produce containers
  - ☐ 3-4 paper towel tubes
  - ☐ Any number of bottle caps
  - ☐ 3-4 small- or medium-sized boxes
  - ☐ 1-2 soda or water bottles, any size
  - ☐ 1-5 discarded CDs
- ☐ Common household supplies (use your imagination and best judgement), such as:
  - ☐ 1 box of aluminum foil or foil cupcake holders
  - ☐ 1 box of colored plastic wrap
  - ☐ 1 box of toothpicks
  - ☐ Any amount of tinsel or ribbon
  - ☐ 5-10 straws
  - ☐ 1 package of beads
  - ☐ 1 package of buttons
  - ☐ 2-5 different-sized reused Styrofoam blocks
  - ☐ 1 package of chenille sticks
  - ☐ 1-3 toys with wheels (for rovers)
  - ☐ 1-2 feet of fabric or gauze
  - ☐ 1-5 erasers
  - ☐ 1 package of wooden spools or wooden miniatures
  - ☐ Any amount of clay or Play-Doh

Alternatively, expand the scale of this activity so that participants may move around within their model structures. Provide large-scale items such as empty appliance boxes, masking tape, paper plates (to create circular "windows"), construction paper, markers, chalk, and other supplies.

One option is to design a large scale model, such as this model of the International Space Station. Children added modules and signs throughout.

Supporting Resources

Consider setting up a digital device (such as a computer or tablet), speakers, and access to the Internet to display websites or multimedia before or after the activity.

Books:

Bennett, Jeffrey (2008-2015). *Science Adventures with Max the Dog* series. Big Kid Science. Grades 2-4; fiction

Gibbs, Stuart (2013-2016). *Moon Base Alpha* Series. Simon & Schuster Books for Young Readers. Grades 3-7; fiction

Roach, M. (2011). *Packing for Mars: The Curious Science of Life in the Void*. New York, NY: W. W. Norton & Company. (Paperback ISBN 978-0-3933-3991-8). Appropriate for adults

Yasuda, A. (2015). *Astronomy: Cool women in space*. White River Junction, VT: Nomad Press.
(Hardcover ISBN 978-1-6193-0326-3, Paperback ISBN 978-1-6193-0330-0) Grades 4 – 6

Websites:

NASA's Be a Martian
http://beamartian.jpl.nasa.gov/welcome
Be a Martian and get the latest Mars news, images, and information and be part of a community of explorers.

Globus, Al (May 07, 2016). "Space Settlement Basics."
http://settlement.arc.nasa.gov/Basics/wwwwh.html

Will We Ever Colonize Mars?
http://www.universetoday.com/14883/mars-colonizing

Video Clips:

European Space Agency Video: Building a Moon Base
https://www.youtube.com/watch?v=E-lq2ErdIXY

NOVA video: Extreme Temperatures on the Moon
http://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.extemp/extreme-temperatures-on-the-moon/

NASA videos: A Day in the Life Aboard the International Space Station
https://www.nasa.gov/audience/foreducators/stem-on-station/dayinthelife

Images:

Pat Rawlings Space Art
http://www.patrawlings.com
Some images follow the NASA media usage guidelines and may be used for educational or informational purposes. Please note the copyright status of the specific image of interest.

Slideshow:

Understanding Martian Resources and Environmental Constraints
http://mars.nasa.gov/participate/marsforeducators/soi/resources/MarsSOI2012_Lesson4_pres1.ppt

Preparation

Advanced Planning Tips:

- **If possible, incorporate additional science, technology, engineering, art, and mathematics (STEAM) activities into the event. See the STAR_Net resources listed at www.starnetlibraries.org for ideas.**
- **Prepare and distribute publicity materials for programs based on this event.**
- **Pull supporting resources out of circulation to feature during the program.**

- Provide a large area where the children may design and create their space colonies. Each group of three to four children will need to work at a table.
- Set out the craft supplies on a table where all of the groups can access it.
- Set out the *Be Creative* poster (or hang it on a nearby wall).

Activity

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already know each other).

- Frame the activity with the main message: Makers and engineers — like the participants — have creative ideas for building the colonies that astronauts need to explore our solar system.

- Set the stage for the activity by discussing space colonies and what astronauts need to survive on a space station or on the Moon, Mars, or an asteroid. If desired, write their suggestions on a board or have small groups of participants list and/or draw ideas on paper at their tables. Facilitate a conversation about the following points:

  – In order to survive and thrive, humans need food, water, shelter, air, social interactions with family or friends, and ways to have fun;

  – On Earth, the infrastructure of our civilization provides communication, transportation, energy, water, and waste systems.

Prompt the participants to draw on prior knowledge about survival and space environments. For example, participants might think about the need to bring your own food, water, and shelter when camping.

As much as possible, encourage the participants to share their own thoughts and experiences, and to respond to each other's questions throughout this activity. Responses could include:

- That's a great question! Does anyone have an answer?
- Interesting what do the rest of you think about what __________________ said?
- What do you think would happen if we tried that?

This discussion will help participants focus on the elements they must ensure are included in the design of their space colony. Let them lead as much as possible. However, make sure that they identify the major elements, perhaps with leading questions about how they will meet a particular need (like food).

- Together, identify some of the challenges to living on the Moon, Mars, an asteroid, or in space. Participants may mention or discuss some important characteristics, such as:
  – Mars is very cold. The average nighttime temperatures on the Moon are extremely cold, while it can become very hot on the Moon in daytime.
  – Explorers in space and on the Moon, Mars, or an asteroid would be exposed to dangerous amounts of radiation from the Sun, which can damage body tissues.
  – The Moon has no (significant) atmosphere and Mars' atmosphere is very thin and poisonous.
  – There are no sources of food or fresh water.
  – However, both the Moon and Mars have gravity that will hold humans to their surfaces while they live and explore there.
- Together, choose where the audience would like to build their colony: in Earth orbit or on the Moon, Mars, or an asteroid. Alternatively, select the location for them.

2. Optional: Read a fictional story about space colonies, such as a Moon or Mars base, geared for the age of the audience.

This activity is intentionally open-ended to encourage creativity. However, providing context is important for attracting the interest of girls and other underrepresented groups in science, technology, engineering, and mathematics (Halpern et al., 2007).

References

Diane F. Halpern et al (2007). *Encouraging Girls in Math and Science: IES Practice Guide*.
U.S. Department of Education. www.ies.ed.gov/ncee/wwc/pdf/practice_guides/20072003.pdf

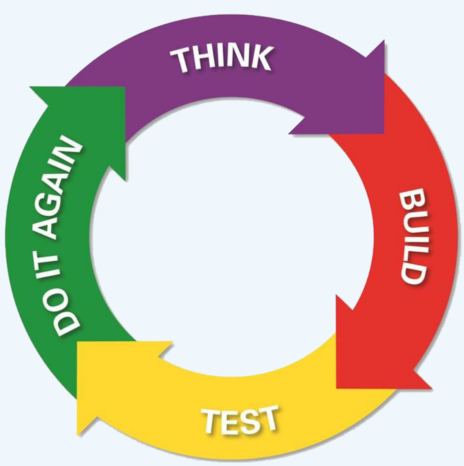
3. Invite the participants to design, build, and iteratively test a model of a space colony that provides the same support systems as on Earth. Explain that each family or small group will contribute one component to the overall space colony.

Describe the types of craft materials that are available for them to use. Encourage groups to use the engineering design process, where they methodically improve one aspect of their component at a time. Finally, have them label their components, denoting the function of each area.

Have tweens determine the scale of the model colony and construct their components to the same scale (for example, one inch equals one foot).

Each family or small group might contribute one of the following components:

- Habitation Modules – living quarters that may include showers, private rooms, eating areas, etc.
- Laboratory Modules – to conduct experiments
- Greenhouses – to grow food and transform carbon dioxide into oxygen
- Solar Arrays – to collect and store electricity
- Antennas – for communications back to Earth and with other spacecraft
- Surface Rovers – pressurized or open rovers for long and short trips
- Mining Facilities – to mine and transform resources
- Docking Facilities – for supply ships
- Escape System – in case of an emergency



Guide the participants through the engineering design process as they work. Adjusting and retesting their ideas is the best way to experience the ongoing work of an engineer! As time allows, emphasize this stage of the engineering design process as much as possible. They will be rewarded by seeing improvement.

Reassure the participants that there isn't a "right" answer that they must arrive at on the first try. Furthermore, failure is an essential part of figuring out what works and what doesn't. It is OK to fail — and try again . . . and again . . . and again!

Activity (continued)

4. Conclude.

Display the assembled components as the space colony. Have each family or small group describe their model components — as well as their challenges and successes in the engineering design process — to the audience.

Have a deeper reflection on the complexity of designing a space colony with prompts such as:

- How did your component change as you worked together to design it?
- Should building a space colony be an international project? Why or why not?
- How do the different components help astronauts to survive and explore in your space colony?
- If you were living in a space colony what would your life be like? How would it be different?
- What changes to your component would you make with additional time?
- What other components would you like to see added to the space colony?

Correlations to the Next Generation Science Standards

Assessment Standard

Engineering Design

Students who demonstrate understanding can:

- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Structure and Properties of Matter

Students who demonstrate understanding can:

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Different properties are suited to different purposes.
- A great variety of objects can be built up from a small set of pieces.

ESS3.A Natural Resources

- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.

ESS3.B Natural Hazards

- A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts.

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

Correlations to the Next Generation Science Standards

Science and Engineering Practices

Asking Questions and Defining Problems

- Define a simple problem that can be solved through the development of a new or improved object or tool.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

Developing and Using Models

- Develop a simple model based on evidence to represent a proposed object or tool.

Using Mathematics and Computational Thinking

- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.

Crosscutting Concepts

Systems and System Models

- A system can be described in terms of its components and their interactions.

Energy and Matter

- Objects may break into smaller pieces and be put together into larger pieces, or change shapes.

Structure and Function

- The shape and stability of structures of natural and designed objects are related to their function(s).

The Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Scientists use drawings, sketches, and models as a way to communicate ideas.

Science is a Human Endeavor

- Most scientists and engineers work in teams.
- Creativity and imagination are important to science.

Science Addresses Questions About the Natural and Material World

- Scientific knowledge is constrained by human capacity, technology, and materials.

Facilitator Background Information

Space Colonies

Space colonies on the Moon, Mars, asteroids, other worlds and in orbit around the Earth have been suggested, designed and promoted since the 1950's. There are a great many things we can do on other worlds and in Earth orbit. We can set up mining stations on the Moon, and fund laboratories in space to perform experiments you wouldn't want to do on Earth because of the risks involved to the population. We can also build observatories and factories in space.

A space colony might include three types of modules: habitation, laboratory and factory modules. The habitat would have sleeping quarters, a kitchen (or galley) and bathroom facilities. Any windows (if any) would have to be small and made of multiple thick glass sheets to block cosmic radiation.

The modules would be filled with air to enable the crew to breathe, and pressurized like an airplane cabin at a pressure of one Earth atmosphere. Energy, oxygen, food, and water necessary to maintain life would have to be transported from the Earth. Research and experiments would be conducted to find ways of producing or recycling some of these essentials onsite. For example, sunlight can be utilized to supply energy, and oxygen could be produced from oxide compounds existing on the Moon or from Mars' thin carbon dioxide atmosphere. Settlers would grow plants and possibly breed fish or birds.

In addition to living quarters, a space colony would also need a landing/launch pad, a power plant - either solar or nuclear, construction equipment, a spare parts and maintenance garage, a central control and communications center, and life support systems. Mining equipment and a solar oven could be used in building the initial lunar base and then be employed for supplying material for industry in orbital space.

Parts of Space Colonies

- **Laboratory Modules** - The crew work quarters, where experiments on materials and living things will take place.
- **Habitation Modules** - These will have living quarters for the crews and may include a shower, private compartments, and a galley (eating area).
- **Greenhouses** - Used for growing food and contributing to the oxygen system, also a way to use excess carbon dioxide.
- **Solar Arrays** – To collect and store up electricity to power the various base systems and experimental activities.
- **Antennas** - Used for communication back to the Earth and with arriving and departing spacecraft.
- **Surface Rovers** - Pressurized rovers can be used for long journeys, simpler open rovers can be used for short trips.
- **Resource Utilization Facilities** - Used to mine the resources of the moon or planet for use in the base, or for manufacturing propellant (fuel) for space ships.

Facilitator Background Information (continued)

- **Telescopes** - On the Moon where there is no atmosphere, telescopes would provide scientists and astronomers a great view of deep space beyond Earth's atmosphere.
- **Supply Ships** - Spacecraft used to bring crews and supplies to and from the space base.
- **Space Suits** - Astronauts will need to wear space suits for construction and repair of the space base, either on the Moon or Mars or on an orbiting space base (although the construct of each may be slightly different due to different conditions).

Colony Needs

- **Air:** The modules will have to be enclosed or the entire living area must be inside a protective dome. Oxygen can be produced mechanically (from water or certain minerals) or by plants in a greenhouse.
- **Food:** There are no grocery stores in space, and it is too expensive to send food from Earth. The colonists will need to grow their own crops; scientists and engineers are investigating the best plants. Crops can also be used to purify water and to produce oxygen from carbon dioxide using photosynthesis. They could be grown in a greenhouse.
- **Water:** Colonies will need a great deal of water for many purposes, including drinking, washing, and watering plants. Where will you get the water? How will it be stored? A recycling facility may be needed.
- **Energy:** What energy source(s) will power the space colony? Will it be solar or nuclear? What about a back-up system?
- **Equipment:** What work will your colonists be doing? Will there be mining? Science laboratories? Telescopes?
- **Living Quarters:** Consider whether each colonist needs a private living space. Every square foot of the base requires more resources, but people are happier when they feel they have sufficient space and privacy.
- **Communications:** How will the colonists communicate with one another, including with explorers using a rover to travel a distance from the colony? How will they communicate with the Earth? On Earth, antennas are used to send and receive signals, and satellites are used to relay signals to other parts of the planet.
- **Transportation:** What kinds of trips will the crews need to make? How far will they need to go? What should they use for fuel?
- **Recreation Facilities:** On Earth, gravity pulls against us when we walk, run, and play ball and helps us stay strong! Colonists will need to exercise more to keep their muscles and bones from losing strength in the lower gravity, which is weaker on the Moon (one-sixth that of Earth) and on Mars (one-third that of Earth). How will the colonists exercise?

Brief Facilitation Guide

Download the full activity guide at www.starnetlibraries.org

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  – On Earth, the infrastructure of our civilization provides communication, transportation, energy, water & waste systems.

- Together, identify some of the challenges to living on the Moon, Mars, an asteroid, or in space. Participants may mention or discuss some important characteristics, such as:
  – Mars is very cold. The average nighttime temperatures on the Moon are extremely cold, while it can become very hot on the Moon in daytime.
  – Explorers in space and on the Moon, Mars, or an asteroid would be exposed to dangerous amounts of radiation from the Sun, which can damage body tissues.
  – The Moon has no (significant) atmosphere and Mars' atmosphere is very thin and poisonous.
  – There are no sources of food or fresh water.
  – However, both the Moon and Mars have gravity that will hold humans to their surfaces while they live and explore there.

2. Optional: Read a fictional story about space colonies, such as a Moon or Mars base, geared for the age of the audience.

3. Invite the participants to design, build, and iteratively test a model of a space colony that provides the same support systems as on Earth.

Explain that each family or small group will contribute one component to the overall space colony. Describe the types of craft materials that are available for them to use. Encourage groups to use the engineering design process, where they methodically improve one aspect of their component at a time. Finally, have them label their components, denoting the function of each area.

4. Conclude.

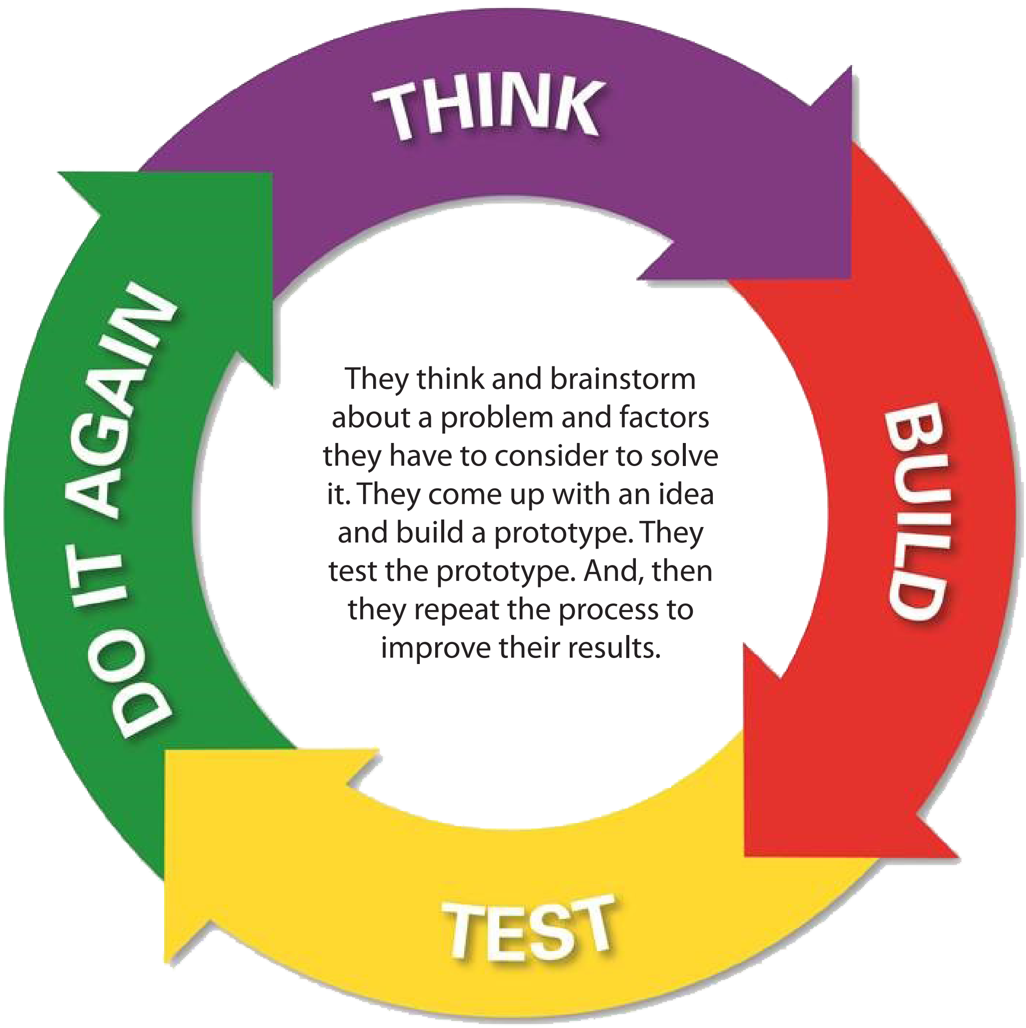
Display the assembled components as the space colony. Have each family or small group describe their model components — as well as their challenges and successes in the engineering design process — to the audience.

Build A Space Colony

Be Creative... Be an Engineer!

Think, build, test, do it again. That's the process engineers use when they tackle a problem.

Engineers don't have official rules telling them to follow this set of steps. But, over time they've learned that they get the best results this way:



Engineers often move back and forth within the loop, repeating two steps over and over again before moving forward. It's a key to engineering success.

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