Lesson Plan 5: NASA Engineering Design:Construct a Tomatosphere Greenhouse

Engineering Design Challenge:

To design and build a greenhouse that astronauts can use to grow tomato seeds during long term space travel.

Length: 5-7 days

Next Generation Science Standard HS-LS1-5:

- Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Common Core State Standard Math.Content.HSG.MG.A.3f:

- Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Objectives:

- Students will identify how a greenhouse maintains humidity and temperature for plants to grow.
- Students will demonstrate understanding of the NASA design process.
- Students will demonstrate teamwork during a design challenge.

Materials:

- Tomatosphere plants and pots
- Measuring Tape (1 per group)
- Rulers (1 per group)
- NASA BEST Kit (optional; see resources)
- Engineering Design Challenge Worksheet (1 per group)
- Duct tape

Suggested Materials for Greenhouse:

Greenhouse Cover		PVC Pipe Cutter	
PVC Pipes		Thermometer	
PVC Elbow Socket		Optional: Seedling Heating Pad	

Motivate:

Begin asking students about engineering. Consider the following questions:

1. "What does an engineer do?"
2. "Describe some engineering designs that you have noticed."
3. "How do you think engineers bring ideas to life?"

Teachers can provide an example of NASA engineers solving problems quickly during the Apollo 13 moon mission.

"Apollo 13 was a NASA mission to the moon. Unfortunately, an oxygen tank exploded 200,000 miles from Earth. The astronauts were able to use another part of their ship to survive, but they were running out of oxygen fast. They needed to find a way to put a square filter on a round oxygen vent. They turned to NASA engineers to solve the problem." Show the following:

https://www.youtube.com/watch?v=ry55--J4_VQ&list=PLZbXA4lyCtqoXIQDJX6ARM1eoTNAJEWCf

To further student understanding, teachers can use this engineering example to further student understanding:

https://www.youtube.com/watch?v=TwVsZD3Hsuk

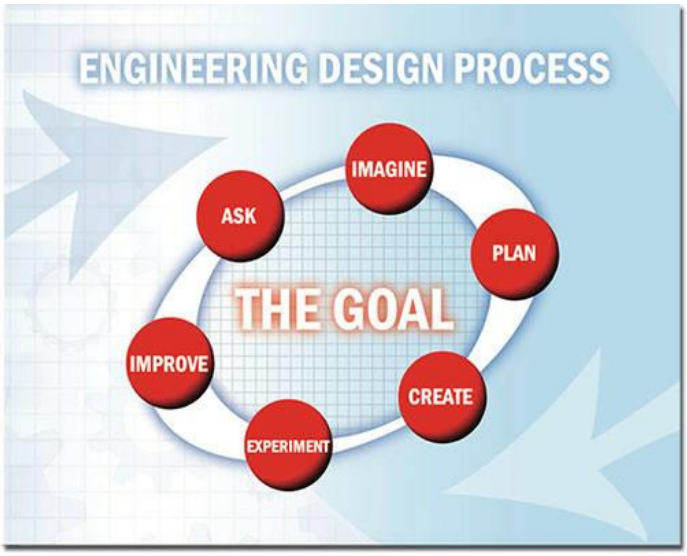
Introduce the Challenge:

Today we are going to be engineers, similar to the engineers in the videos we saw today. We will build a greenhouse to grow tomato plants. The greenhouse is meant to simulate astronaut engineers trying to grow plants on the Moon or during long space travel. Discuss and show examples of greenhouses. Mention that greenhouses trap heat energy to maintain consistent temperature (75-80F) and humidity (50-70%). *Note: It's best if teachers distribute thermometers that measure temperature and humidity. If that is not available, the teacher should have at least one for students to share to frequently monitor humidity.*

Each student will use their Chromebooks to learn about the engineering process. Use the following websites:

https://pbskids.org/designsquad/parentseducators/training/index.html

https://www.nasa.gov/audience/foreducators/best/edp.html



Ask:

Students clarify the question. Students discuss limitations, what materials to use, what temperature should the greenhouse maintain, etc.

Imagine:

Students will brainstorm how they will construct a greenhouse. All ideas are accepted during this step. Research is included in this step.

Plan:

Students discuss and choose the best design. They will discuss limitations and resources available to them. Students will draw their best design on paper. All designs must include design dimensions and a set of directions. All designs must be approved by the teacher before building begins.

Create, Experiment, Improve:

Students will collect materials and begin building. The experiment step includes monitoring temperature, humidity and structure height for plant growth.

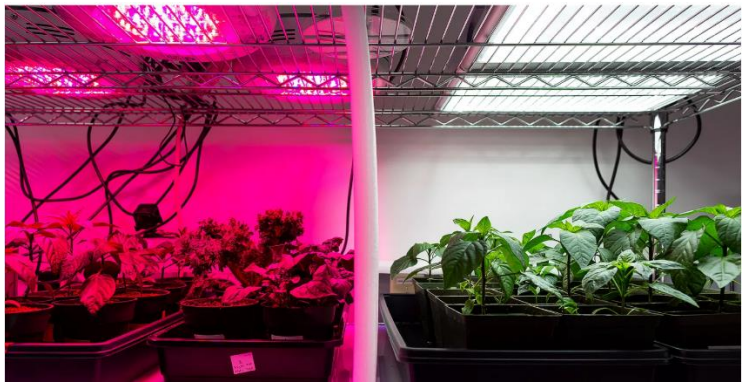
Discuss what happened:

As a class, students present their designs to the class. During each presentation, students include challenges and solutions. Students will also discuss how the NASA design challenge helped them understand the engineering process more clearly. Students turn in the Design Challenge Worksheet.

Extend the Challenge:

Students can replace the clear plastic covering with black out covering. Inside their black out greenhouse they can install red and blue LED lights. After the plants begin to grow, students can compare the black leaves of the tomato plants with the green leaves of the tomato plants that grew with the clear plastic covering. One excellent source for more information can be found at:

https://www.theverge.com/2018/9/21/17883780/nasa-veggie-plants-space-station-mars-moon-soil-food



Students can use a variety of materials to build their greenhouses: plastic sides, waterproof wood, etc.

Design Challenge Performance Assessment Rubric:

Challenge Name: _____

Names of Team Members: _____

Identifying the problem (s) and brainstorming solutions	Showed a clear understanding of the problems to solve.	Needed some teacher direction to define the problem and brainstorm possible solutions.	Needed a lot of teacher support to define the problem, brainstorming and solutions.
Working as a team member	Worked well together. All team members participated and stayed on task.	Some team members were occasionally off task.	Most team members were often off task and not cooperating or participating fully.
Using the design process	Team brainstormed many ideas, tested, and improved the designs. Final design complete. Shows creative problem solving.	Some team members were occasionally off task.	Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design ideas.
Processing the science and engineering	Team gave a strong presentation of its solutions and understanding to the design challenge.	Team gave a basic presentation of its solution to the challenge and show basic understanding of the design process.	Team gave a weak presentation of its solution to the challenge and showed little understanding of the design process.

Source: pbskids.org/designsquad

Resources:

https://er.jsc.nasa.gov/seh/main_EDC_Lunar_Plant_Growth_Chamber.pdf

https://farmplasticsupply.com/index.php?route=common/home

In addition, for your convenience, a NASA BEST Kit is available for purchase from Science Kit/Boreal Laboratories (www.sciencekit.com/ NASABEST/), which supports ~30 students.