MACGILLIVRAY FREEMAN'S

DREAM BIG

ENGINEERING OUR WORLD

GRADE 6:

DESERT ISLAND DESALINATION

Grade level: 6

Lesson length: 160 minutes (can be broken down into multiple class periods)

Testing phase of lesson: At least 5 hours

Students are challenged to create a source of freshwater on a desert island using only the material and energy resources available to them.

In the Film

As the human population continues to increase, engineers are challenged to create structures that help our community adapt to limited space and limited resources. In the film *Dream Big*, we see ways that engineers adapt our energy systems to no longer rely on limited fossil fuels. In this challenge, we will build on this foundation. We will produce clean, fresh, drinkable water from salt water using only the energy from the sun.

NGSS Disciplinary Core Ideas

MS-PS4.B Electromagnetic Radiation

When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

MS-PS1.A Structure and Properties of Matter

Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.

MS-ESS2-4 Develop a model to describe the cycling of Earth's water through Earth's systems driven by energy from the sun and the force of gravity.

NGSS Engineering Practices

MS-ETS1.A Defining and Delimiting Engineering Problems

The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will work. Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions.

MS-ETS1.B Developing Possible Solutions

A solution needs to be tested, and then modified on the basis of the test results.

There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.

Dream Big: Engineering Our World is a film and educational project produced by MacGillivray Freeman Films in partnership with the American Society of Civil Engineers and presented by Bechtel Corporation. The centerpiece of the project is a film for IMAX and other giant screen theaters that takes viewers on a journey of discovery from the world's tallest building to a bridge higher than the clouds and a solar car race across Australia. For a complete suite of *Dream Big* hands-on activities, educational videos, and other materials to support engineering education, visit discovere.org/dreambig. The *Dream Big* Educator Guide was developed by Discovery Place for the American Society of Civil Engineers.

Key Words/Vocabulary

Evaporation: The process whereby liquids absorb energy and change to a gas. Like condensation, this process also occurs most often due to a rapid change in temperature and/or pressure.

Condensation: The process whereby vapor loses energy and changes from a gas to a liquid. This usually occurs due to a rapid change in pressure and/or temperature.

Solution: A mixture of at least two pure substances where one is dissolved in another.

Pure substance: A substance that cannot be broken down into simpler components without undergoing a chemical change.

Precipitation: Any form of water that falls from clouds and reaches Earth's surface. In order for precipitation to occur, water must undergo a phase change from vapor to liquid.

Phase change: Any time there is a transition in a substance between solid, liquid, or gas.

Materials

Per group:

- ☐ Clear plastic painter's drop cloth or clear sheet of plastic, 3' x 3'
- ☐ Miscellaneous recycled objects (plastic water bottles, 2L bottles, plastic/paper cups, plastic bags)
- ☐ 6 dowel rods (36" long each)
- ☐ 10 rubber bands
- ☐ 1L beaker of water dyed with food coloring to represent salt
- ☐ 1 collection beaker for freshwater (Note: make sure it's clean, as students may be tasting their product)

Per student:

- ☐ Solar Desalination Device Engineering Sheet

Extension Materials:

- ☐ Cardboard
- ☐ Aluminum foil

Teacher Prep Notes

Before students build the frame to collect evaporated water, have them practice building frames using the rubber bands and dowel rods. For ideas on how to do this and designs that students could make, check out this video from COSI: learnxdesign.org/learnxdesign_record/dowels-and-rubber-bands-ii

Make enough copies of the Solar Desalination Device Engineering Sheet for each student. Note that students will fill in different sections as they work through the steps of this activity.

Prepare to teach students about the Earth's water cycle (note that there are educational videos online). You will need to explain how the sun provides the energy for water to change phase, covering the evaporation of water as a pure substance and its precipitation as freshwater into the surface water system.

Decide how you want students to research desalination plants. They will be comparing what they learn to the workings of the water cycle to help them create their devices.

Optional: Gather images and suggestions of ways to distill freshwater using the sun for students to use as inspiration.

To Do

Determine the Problem or Question to Solve: 15 minutes

1. Before watching the film *Dream Big*, give students an overview of what they are about to experience. This film is about engineering and the ways that engineering can inspire, challenge, and enrich our lives. Give students the following question to think about as they are watching the film:
   - How are engineers solving the issues that humanity faces as our population continues to grow at a faster and faster rate?
2. Debrief as a whole class after viewing the film, touching on the question you gave them to think about.
3. Introduce the design challenge: In groups, students will design a device that provides clean drinking water from salt water through a process called desalination.
   - This process will use the same basic process that the Earth's water cycle uses to provide clean and fresh water, using only energy from the sun.
   - Each group will receive 1 liter of water (dyed with food coloring to represent salt) in a beaker to place in the sun.
   - The device students create must catch the evaporated water, allow it to condense, and collect it in a separate container.

Research and Gather Information: 60 minutes

1. Give an overview of the Earth's water cycle. Describe, or show, how the sun provides the energy for water to change phase, how water evaporates as a pure substance, and how it precipitates as freshwater into the surface water system.
2. Organize students into small groups. Instruct students to research and examine current desalination plants. Tell students to note in their group the similarities between desalination plants and the water cycle. Then discuss as a class, making sure students understand these comparisons: Both use heat to change the phase of water to a gas, and both condense the water vapor as a pure, drinkable substance. Review this key difference: Desalination plants use fossil fuels instead of the sun as an energy source.
3. Review the materials available for this challenge: plastic sheeting, dowel rods, and rubber bands. Give students time to brainstorm ways that they could put the materials together to catch the evaporated water, allow it to cool, and send it to a collecting beaker.
4. Optional: Do a web search for images or ways to distill freshwater using only the sun and share these with students. Tell groups to use these images or ideas to help them imagine how they could make something similar with their materials. Push students to use the scientific knowledge they gained in studying the water cycle, phase change, and desalination plants.
5. Ask students to reflect on their research and information gathering and to write their thoughts in the "Research and Gather Information" section of their Solar Desalination Device Engineering Sheet. Have students share their thoughts and concerns about the challenge, criteria, and constraints of the design as the project moves forward. If students are unfamiliar with the concepts of criteria and constraints in engineering, take the time now to introduce these two key ideas. Engineers look at challenges through the lens of criteria (what does my device have to do?) and constraints (what are the limitations I face in making, testing, and using the device?). Spend some time with students as a whole class brainstorming the criteria and constraints of this particular engineering challenge.

Plan a Solution: 15 minutes

After brainstorming shapes that they can make with the dowel rods and plastic, tell students to fill in the Plan section of their Solar Desalination Device Engineering Sheet, which involves drawing an image of what they plan to create. Groups should also write a step-by-step process for how their device will be built and deployed. Based on their knowledge of the desalinization process and the water cycle, students should be able to describe how water can change phases within their device and how that mimics the phase changes of the global water cycle.

Ask each group to share their plan with the class and discuss these questions:

- Which elements of your design are you most confident about?
- Which elements of your design might fail?

Make It: 30 minutes

Once students have drawn their plan, it's time to begin building. As students are building, visit each group, reviewing what they learned about evaporation and condensation in the water cycle. Ask students questions about how they are trapping the water vapor to keep it from escaping into the atmosphere, how they are cooling it, and how they are having it flow down into one specific area, the collection beaker. Allow students to make mistakes along the way and struggle. When they do, ask questions about what they observed and what they could change to fix the problem. Avoid offering solutions and instead encourage students to test ideas as they build.

Test: 20 minutes

Test Timeframe: At least 5 hours

Each group will start the project with a bowl or container of one liter of water dyed with food coloring to represent the salt. Students should place that container inside of their device, outside the school, on a sunny day, and likely over a long period of time. The recommended timeframe is at least 5 hours, depending on exterior temperature. Students should gather the freshwater that has been accumulated through the experiment in a separate, clean container, "the collection beaker".

Evaluate: 20 minutes

Have students assess their device by answering the questions in the "Evaluate" section of the Solar Desalination Device Engineering Sheet.

If students are feeling adventurous, have them taste their water and reflect on its palatability.

Taking It Further

Extend the impact of your device: Students should be given the opportunity to reiterate their original design and develop a successful desalinization model. Prompt students to reflect on the information you learned as a class regarding which parts of each model were useful, in order to create a new, more effective design. Engineers are constantly refining designs based on experience and new information. Students can develop reflective surfaces to increase the solar radiation that hits their salt water and speed up its output of clean water. Use cardboard and aluminum foil to create reflective surfaces for them to integrate into their design.

Learn about this engineering in the real world: Cities along the coast are not the only areas that are challenged with desalinating their water. In the central valley of California, farmers and residents are facing one of the worst droughts in history. Additionally, the soil content of this area of the United States is unusually high in salt content. When it rains, the fresh rainwater mixes with the salt in the soil to create an unusable saltwater source. Engineers are working on ways to use the solar energy from this area to desalinate the rainwater runoff. Learn about the machines they are engineering, the tests they are conducting, and the challenges they face by visiting this site: waterfx.co

Document your students' work through our social media outlet: #dreambigfilm

SOLAR DESALINATION DEVICE ENGINEERING SHEET

Name: _____

Problem to Be Solved

Create a device that can desalinate water using only the energy from the sun.

Research and Gather Information

1. What do we know about how the Earth naturally desalinates salt water to make freshwater?

2. How are desalination plants similar to the Earth's natural process?

3. How are desalination plants different from the Earth's natural process?

4. Brainstorm: How can you use only dowel rods, plastic sheeting, and rubber bands to capture the vapor from a bowl of salt water, condense it, and force it to flow into a collection beaker?

Plan

☐ The criteria of the engineering and design challenge are:

☐ The constraints of the engineering and design challenge are:

☐ Draw a picture of what you plan to make.

☐ Write a step-by-step process of how to create your design.

☐ Describe how water changes phases within your device and how that mimics the phase changes of the global water cycle.

Make It!

Evaluate

Did your device meet the constraints of the engineering challenge?

Did your device meet the criteria of the engineering challenge?

Did it create fresh, drinkable water?

- What was the volume of water it created?
- What volume of salt water was still left in the original basin?
- What volume of water escaped into the atmosphere? (The original volume of 1 liter, minus the volume of water created and minus the volume of water still left in the original basin)

What was the major failure point of your device?

- Where was it the weakest?
- Did it fall over?
- Did it let too much evaporated water escape?

What would you do differently next time?

DREAM BIG VIDEO SERIES

WATCH *QUENCHING A THIRSTY WORLD: WATER ENGINEERING*

With limits on our freshwater supply and a planet with more than 7 billion people, we need the ingenuity of engineers to produce drinking water from improbable sources. Discover how engineers are quenching the world's thirst with creative solutions. Go to discovere.org/dreambig/media-assets and visit Educational Webisodes.

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