TGR EDU:
EXPLORE

MIDDLE SCHOOL

PROJECT PIPELINE

FRESHWATER IMPACT

TGR FOUNDATION
A TIGER WOODS CHARITY

Discovery
EDUCATION

LESSON OVERVIEW:

Did you know that only 3.5% of Earth's water is freshwater, and over 98% of that water is locked up in ice, glaciers,and groundwater?[1] Humans, plants, and animals need freshwater to survive, so it is crucial that scientists and engineers can devise ways to bring Earth's limited supply of freshwater to populations that need it.

In this lesson, students will create models of freshwater pipelines to simulate the transmission of freshwater from the Colorado River to a town in Southwestern California. They will learn how scientists and engineers work together to protect Earth's freshwater supply and employ the basic properties of water to create an effective pipeline model. Students will then role-play different careers and work through the engineering design process as they develop possible solutions.

THIS LESSON FOCUSES ON:

ENGINEERING DESIGN PROCESS	21ST CENTURY SKILLS
○ **Defining the Problem**	○ **Collaboration**
○ **Designing Solutions**	○ Communication
○ **Creating or Prototyping**	○ **Critical Thinking**
○ **Refine or Improve**	○ Creativity
○ **Communicating Results**	

OBJECTIVES

Students will be able to:

- ○ **Identify** the properties of water and **apply** them to a freshwater pipeline simulation.
- ○ **Evaluate** the effectiveness of their pipeline design.
- ○ **Create** a solution that factors in global limitations.

MATERIALS

○ Engineering Design Process Model	○ Duct tape
○ Computer	○ Masking tape
○ Projector	○ Markers
○ Screen	○ Meter stick
○ 2 cups	○ Poster paper
○ 100 mL of water	○ Scissors
○ Beaker	○ Straws
○ Cardboard tubes	

HAVE YOU EVER WONDERED...

How the water that comes out of our kitchen taps gets to us?
Because most of us live in major metropolitan areas, our water supply is managed by our towns and cities.[2] For most cities, the water supply comes from a river that is dammed to form a reservoir, usually at an altitude that is higher from that of the city. From here, gravity leads the charge! A series of pipes works to transport the water down from these reservoirs and into your faucet at home.[2]

Why natural events that happen hundreds of miles away impact your water systems?
Sometimes, water has to travel a long distance before it reaches its destination. For instance, the Colorado River system is a major supplier of drinking water to the southwestern United States. The water that flows through the Colorado River comes from a variety of places, including the snowfall on top of the Rocky Mountains. If the mountains get less snow, less water will flow through the river. When less water flows through the river, people as far away as California have less water to drink and use.[3]

Who's working behind the scenes to make sure we have the clean, fresh water we need every day?
From environmental engineers to physicists, from chemists to construction workers, there are a variety of people working to make sure that freshwater is available and safe to use. As we dive into the lesson, we'll learn about many of the different careers that make an impact on our freshwater systems.

MAKE CONNECTIONS!

This section captures how this activity connects to different parts of our lives and frames the reason for learning.

HOW DOES THIS CONNECT TO STUDENTS?	HOW DOES THIS CONNECT TO CAREERS?	HOW DOES THIS CONNECT TO OUR WORLD?
Students use water each and every day for a variety of needs. This lesson will help students think about water in micro and macro perspectives by shining a light on how the water they use arrives in their homes and how engineering marvels cover great distances to supply entire regions with this important life force.	**Engineers** from a variety of fields (civil, environmental, material science, etc.) assess the usability of freshwater, design structures to transport it and harness hydroelectricity created by freshwater to power our cities. **Scientists** like climatologists, physicists and chemists assess weather patterns, devise new methods for cleaning freshwater and use water's basic properties to advance scientific inquiry. **Construction specialists** build reservoirs, water towers, and metropolitan plumbing grids to bring freshwater to the homes, offices and buildings where it is needed. **Climatologists** study Earth's climate. They collect and analyze data from soil, water, and air to find patterns in weather.	From the food we eat to the places we live, the availability of freshwater impacts us all. As the climate continues to change, it is essential that students understand the basic properties of freshwater, how it gets to us, and how to use it responsibly.

BLUEPRINT FOR DISCOVERY

DAY 1

Whole Group(20 minutes):

1. Engage students by asking them what happens when something goes wrong in the city. (Example: collapsing bridge, broken gas line) What type of engineer is responsible for fixing/solving that issue?
2. Task students to work in small groups to research the responsible party and what their role is in a community. (Students may need more guidance depending on the group.) Students will have 10 minutes to do their research and put together a presentation of their own preference to the whole group. They can use their own devices, computers, or any means necessary to find their information. Make sure students understand that they need to use a credible source.
3. Encourage the groups to be creative with their method of presentation. Provide supplies for the groups to make posters, create a poem, or act out a situation.
4. Discuss with students why a civil engineer is so important in a city. Include the education required, salary, and job description of a civil engineer.

Whole Group (25–35 minutes):

1. Tell students that today's class will be a simulation of a real-world problem: supplying water to drought-stricken Temecula, Calif. The teacher is playing the role of the Secretary of the U.S. Department of the Interior. He/she has come to a conference of scholars and engineers to alert the community to a problem—the water shortage in Southern California. Students will be briefed on the problem and will then form into working groups of scientists and engineers to create a model of a pipeline that will bring freshwater from the Colorado River to Southern California.
2. Begin by pulling up a map of the Colorado River on the projector screen. Highlight the beginning of the river and its tributaries in Colorado and Wyoming.
   Suggested images:
   https://www.doi.gov/water/owdi.cr.drought/en/
   https://water.usgs.gov/watercensus/colorado.html
3. Follow the course of the river to its terminus in Mexico. Explain that from its beginning in Colorado to its ending in Mexico, the river spans 1,450 miles and drops a total of 14,000 feet in elevation.[5]
4. Explain to the class the Colorado River Basin expands across nearly 250,000 square miles—nearly the size of France! The river supplies water to over 33 million people. Ask students to identify which seven states and one country they think are supplied with freshwater from the Colorado River. Correct response is Arizona, California, Colorado, New Mexico, Nevada, Utah, Wyoming, and Mexico.[5]
5. Explain to students that the water supply to many of these arid desert areas is extremely limited and relies on weather patterns. The amount of water in the Colorado River depends on the amount of yearly snowfall in the Rocky Mountains. If there is a year with a light snowfall or a year with less rain, it could mean that many across the Southwest face drought.
6. Display the following maps on the projector or distribute maps to students:
   http://droughtmonitor.unl.edu/data/png/20160301/20160301_CA_date.png
   Explain that, in recent years, California has faced extreme drought conditions. This is because of limited rainfall and a series of lower-than-normal years of snow in the Sierra Nevada Mountains. Citizens and farmers were faced with severe drought restrictions and had to use limited quantities of water.

Ask students to describe the intensity of the drought using the following words in their explanation: dry, moderate drought, severe drought, and extreme drought. Students should use the key provided on the map to help them interpret the information.

Ask students which parts of California are currently experiencing the worst drought conditions. Then, highlight with them the areas of the map facing the worst drought conditions: central and southwest California.

7. Explain that California is looking into many ways to address the issue of limited water supply. Some have proposed building a water pipeline to bring water from areas of ample freshwater into the Colorado River Basin.[6]

8. Explain that pipelines are usually constructed from metal and plastic tubes that are buried underground. They can be anywhere from a few inches to a few feet wide. Sometimes pipelines are raised when traversing difficult land, as with sections of the Alaska pipeline. Ask students what they think might be important to keep in mind when building a water pipeline.

   Answers might include:

   a. How to keep the water clean/safe
   b. How to keep water moving
   c. Maintaining and repairing the pipeline
   d. The weather of the areas where the pipeline will be—desert, mountains, etc.
   e. How to keep water from evaporating or freezing
   f. Environmental concerns with pipeline placement

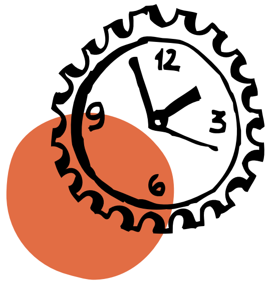
9. Review some of the basic properties of water by inviting students to fill in the blanks:
   a. Water evaporates and turns into a <u>gas (water vapor)</u> when heated to 212 degrees Fahrenheit.
   b. Water <u>freezes and expands</u> when less than 32 degrees Fahrenheit.
   c. Water molecules are highly cohesive and like to <u>stick together</u>. We see this in drops of water and when water vapor condenses to become <u>liquid water</u> again.

10. Tell students that this concludes their briefing and remind them of their mission: build a model of a water pipeline that will transport freshwater from the Colorado River to Temecula, Calif. This model must transport water across the length of one meter without spilling!

11. Form students into teams. Each team will include the following roles:
   a. A civil engineer—responsible for the materials used to build the pipeline and keeping the water flowing
   b. A climatologist—responsible for thinking about the climate in regions where the pipeline will exist and factoring this into the pipeline design
   c. A chemist—responsible for reminding the team of the basic properties of water and devising ways to periodically test the water in the pipeline for safety
   d. A construction specialist—responsible for building and repairing the pipeline

DAY 2

Small Groups (25 minutes):



1. Present to students the **Engineering Design Process Model**. Go over each step of the engineering design process with the students and explain the importance of the whole and its parts.

   Ask students if the engineering design process can be repeated more than once.

2. Allow students to break into groups to build their model using the engineering design process, with each step led by a different member of the group:
   a. Ask (chemist)—What are the problems? What are the constraints?
   b. Imagine (climatologist)—Brainstorm ideas and choose the best one.
   c. Plan (civil engineer)—Draw a diagram and gather materials.
   d. Create (construction specialist)—Follow the plan and test it out.
   e. Improve (as a group)—Discuss what can work better and repeat steps 1–5 to make changes.

3. Distribute the following materials to students; straws, cardboard tubes, 2 cups, duct tape, masking tape, meter stick, scissors, beaker filled with 100 mL of water. Allow 20 minutes for students to complete the challenge.

4. Facilitate the challenge by circling the classroom and allowing additional support to students, as needed.

5. Invite students to test their pipeline with the water provided to ensure they are ready for the challenge.

Whole Group (20 minutes):

1. Once student groups have created and tested their models, have each group "pitch" their model in one minute or less by explaining the design of their pipeline. Encourage students to use the engineering design process to go over the strengths, weaknesses, and what they would do differently if given the chance to rebuild.

2. Ask students to respond to the following questions:
   - What were some challenges you incurred in this activity? What worked well?
   - Do you think building a pipeline from the Colorado River to southwestern California is a good idea to fix the region's freshwater shortage? Why or why not?

TAKE ACTION!

Citizen science projects encourage students to collect data in their own backyard to contribute to larger research efforts. Encourage students to search for Citizen Water Monitoring Programs in their area to participate in.

https://scistarter.com/index.html

NATIONAL STANDARDS

Next Generation Science Standards

Middle School

Science and Engineering Practice

Planning and Carrying Out Investigations

Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.

Developing and Using Models

Develop and use a model to describe phenomena.

Asking Questions and Defining Problems

Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

Analyzing and Interpreting Data

Analyze and interpret data to determine similarities and differences in findings.

Disciplinary Core Idea

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.

ESS2.C: The Roles of Water in Earth's Surface Processes

Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

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 be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

ETS1.B: Developing Possible Solutions

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

Crosscutting Concept

Patterns

Patterns in the natural and human designed world can be observed.

Systems and System Models

Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Influence of Science, Engineering, and Technology on Society and the Natural World

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

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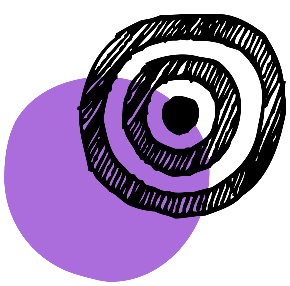

ENGINEERING DESIGN PROCESS MODEL