A Little Water Goes a Long Way

Grade: *6* | ***Time:*** *(2-3) 60 minute periods*

Standards:

Georgia Performance Standards in Science
S6E3.a, b

Next Generation Science Standards
ESS2.C, ESS3.A

Supplies

per student:

- Student Background Info
- Student Lab Report
- Student Evaluation Form

per class (divided equally for 8 teams of 4 students)

- 8 water basins (dish tubs)
- 100 paper straws (15 per group)
- 16 paper or compostable plastic cups
- 8 pcs waterproof Clay (i.e. blue or yellow tac)
- 16 ft Aquarium tubing cut into (8) 2 ft lengths
- 8 rolls Aluminum foil
- 100 Rubber bands (15 per group)
- 8 rolls duct tape
- 1 box toothpicks (15 toothpicks per group)
- 1 pkg Paper clips or binder clips (divided for 8 groups)

Bring your own:

- BYO: Drought Video (see the "Resources" section)
- BYO: method to display video for the class
- BYO: Water (3 cups per group)
- BYO: Glue or glue sticks
- BYO: Assorted glass jars or bowls (2 per group)
- BYO: 8 Measuring cups (one per group)
- BYO: 8 Rulers or measuring tapes (1 per group)

Garden Connection:

Students will test and use their irrigation system designs in the garden to conserve water and grow plants.

STEM Connection:

Students will work in teams on an engineering design challenge to design and build an irrigation system out of everyday items, test their systems, and evaluate their results.

Overview

Students will investigate ways to conserve water in the garden and grow healthy plants during near-drought conditions, test and compare the effectiveness of different water-saving techniques, and implement at least one best practice in the school garden. Students will work in teams to design and build a system to move water from one source to two different delivery areas at least three feet away, using what they know about forces that move water.

Essential Questions

What forces affect the movement of water? How can I design an irrigation system to move water from one source to two different delivery areas at least three feet away? How can water-saving gardening techniques keep plants alive and healthy during a drought?

Engage

The class will watch a short video on droughts and divide into teams to explore the causes and effects that droughts have on plant life. Students will brainstorm watering alternatives for irrigating gardens in drought areas. Students may then complete one or more activities from NASA's "Exploring the Water Cycle" lesson.

Explore

Students will be divided into groups. Each group will be provided information about irrigation systems, irrigation history, Roman aqueducts and ethical implications as they relate to irrigation systems (see attached Student Background Information). Each group will complete an engineering design challenge to build and test a gravity-based irrigation model (see .

Explain

Students will be able to explain (a) forces affecting water movement, (b) irrigation systems, (c) applications for providing water to remote or dry land for growing crops, (d) how irrigation is used to compensate for periods of drought and (e) water conservation techniques in the garden. Each group will be asked to answer the following questions: Can you think of an example of how a team of engineers might have to address ethical considerations related to the environment when building an irrigation system? What do you think the team would have to investigate before starting construction of an irrigation system?

Environmental Stewardship

Students will be challenged to decide on the most efficient irrigation system or the best practice in water conservation that can be implemented on school grounds, and implement that approach in the school garden.

Evaluation

Students will self-assess by completing the Student Evaluation included with this lesson. A rubric is provided to assess student mastery of performance expectations.

Extension

Students may build a moisture-retaining hugelkultur garden and design an experiment to compare plant growth there an in-ground or in a raised bed.

Standards

GEORGIA PERFORMANCE STANDARDS IN SCIENCE

S6E3. Students will recognize the significant role of water in earth processes.

a. Explain that a large portion of the Earth's surface is water, consisting of oceans, rivers, lakes, underground water and ice.
b. Relate various atmospheric conditions to stages of the water cycle.

NEXT GENERATION SCIENCE STANDARDS

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. (MS-ESS2-4)

Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

The complex patterns of the changes and movement of water in the atmosphere, determined by winds, land-forms, and ocean temperatures and currents are major determinants of local weather patterns. (MS-ESS2-5)

ESS3.A: Natural Resources

Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)

Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)

Teacher Background information

- Common Core Frameworks: 6th Grade Role of Water in Earth Processes https://www.georgiastandards.org/Frameworks/GSO%20Frameworks/6%20Science%20Alternative%20Integrated%20Framework%20Task%201%20Water%20In%20Motion.pdf

Resources

- Drought Video/National Geographic http://video.nationalgeographic.com/video/101-videos/droughts

- Water-wise Demonstration Garden http://ucanr.edu/sites/scmg/Water-wise_Gardening/

- Water Science for Schools-U>S> Geological Survey(http://ga.water.usgs.gov/edu/mwater.html

LESSON PROCEDURES

Essential Questions

What forces move water? How can I design an irrigation system to move water from one source to two different delivery areas using what I know about forces that move water, to keep plants alive and healthy during a drought? What gardening practices conserve water in the garden?

Engage

The class will watch a short video on drought (http://video.nationalgeographic.com/video/101-videos/droughts) and then divide into teams to research the causes and effects of droughts on plant life.

Students may complete one or more activities from NASA's "Exploring the Water Cycle" lesson, to learn more about forces that affect the movement of water, including gravity, pressure, and sunlight: http://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/exploring-water-cycle/Exploring%20the%20Water%20Cycle%20TG%20v2.pdf

Explore

Students will be divided into groups of four. Each group will be provided information about irrigation systems, irrigation history, Roman aqueducts and ethical implications as they relate to irrigation systems (see attached Student Background Info sheet). Each group will be asked to consider the following questions: Can you think of an example of how a team of engineers might have to address ethical considerations related to the environment when building an irrigation system? What do you think the team would have to investigate before starting construction of an irrigation system?

Explain

Students will be able to identify (a) which stages of the water cycle require energy from the sun to move water (evaporation and transpiration); which stages of the water cycle give off heat (condensation); and which stages of the water cycle are driven by gravity (precipitation, runoff, infiltration, and groundwater flow) (b) the purpose of irrigation systems, (c) applications for providing water to remote or dry land for growing crops, and (d) how irrigation is used to compensate for periods of anticipated or emergency drought.

Each group should be able to answer the following question: How might a team of engineers might have to address ethical considerations related to the environment when building an irrigation system? Each group will also be able to argue from evidence to advocate for their design of a garden irrigation system.

Environmental Stewardship

The class will select the most efficient irrigation model among those built by student groups and develop a similar system in the school garden.

In addition, students will research and brainstorm alternatives to irrigating gardens during a drought, and adopt at least one water-saving technique to implement in the school garden. Ideas for water-saving techniques may be gleaned from this Water-Wise Gardening web site: http://ucanr.edu/sites/scmg/Water-wise_Gardening. Examples: students may select native plants that require less water than non-native ornamentals; group plants with similar water needs together to reduce water waste; use drip irrigation to reduce evaporative loss; replace turf grass with native groundcovers; mulch around plants to retain water; etc.

Evaluation

Students will self-assess by completing the Student Evaluation included with this lesson. A rubric is also provided to assess student mastery of performance expectations.

Extension

Students may create a hugelkultur garden, and then design an experiment in which they plant seeds and monitor plant growth in the hugelkultur garden, an in-ground garden, and a raised bed garden. Hugelkultur gardens retain moisture and do not generally require watering.

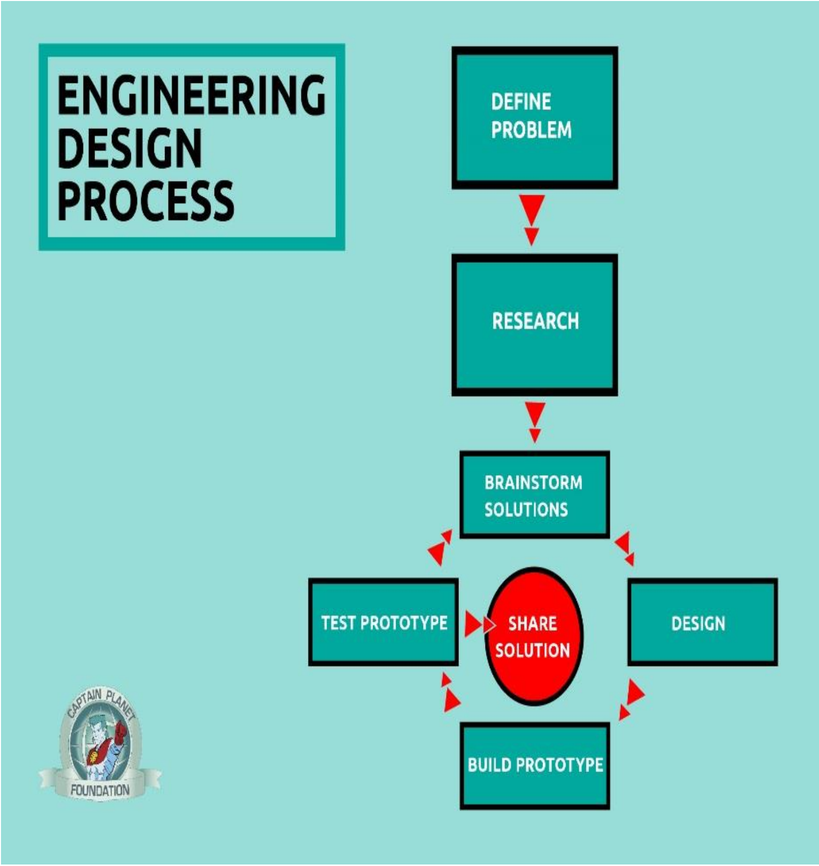
STUDENT BACKGROUND INFORMATION

What is Irrigation?
Irrigation is a system that artificially routes water to an area where it is not naturally present. More common applications are in providing water to remote or dry land to compensate for periods of anticipated or emergency drought, but also is used to protect plants against frost. Irrigation systems are also used to help suppress the growth of weeds in rice fields. There are many different irrigation techniques to route water from a source ot its destination. Usually, uniformity in water placement is a goal, especially for growing crops.

Irrigation History
Archaeologists have found evidence of irrigation at work in Mesopotamia and Egypt as far back as the 6th millennium BCE, where barley was being grown in areas where the natural rainfall was inconsistent or not necessary sufficient to support the crop. In the Zana Valley of the Andes Mountains in Peru, archaeologists have found the remains of three irrigation canals which were radiocarbon dated to place their development at the 4th millennium BCE, the 3rd millennium BCE, and the 9th century CE. At the moment, theses canals are considered the earliest examples of irrigation systems found. In addition, advanced irrigation and water storage systems were developed by the Indus Valley Civilization in Pakistan and North India. Because extensive agriculture was required, an innovative network of canals was developed to support irrigation. There is also evidence of the ancient Egyptian pharaoh Amenemhet III in the twelfth dynasty using the natural lake of the Faiyum Oasis as a reservoir to store water to be used during dry seasons. The lake would swell annually due to the annual flooding of the Nile River. Egypt received little rainfall, so the Nile was a logical source of water.

Roman Aqueducts
The ancient Romans constructed many aqueducts to route water to cities and other sites. These aqueducts are considered to be one of the greatest engineering feats of the ancient world. Many of the ancient aqueducts are still in use today. They served several functions including providing potable water and supplying water to bathes and fountains. Water was then routed into the sewers, where they removed waste matter.

Design Your Own Irrigation System
You are part of a team of engineers who have been given the challenge of developing an irrigation system that will carry two cups of water a distance of at least three feet and split the water equally into two separate destination containers. If your system works, you'll end up with exactly one cup of water in each container. How you accomplish the task is up to your team! Use the Student Lab Report to plan your project and the Student Evaluation Form to assess its effectiveness.



Resources

- Drought Video/National Geographic http://video.nationalgeographic.com/video/101-videos/droughts
- Water-wise Demonstration Garden http://ucanr.edu/sites/scmg/Water-wise_Gardening/
- Water Science for Schools-U.S. Geological Survey http://ga.water.usgs.gov/edu/mwater.html

STUDENT LAB REPORT

Engineering Design Process

Meet as a team and discuss the problem you need to solve as well as any constraints (such as time limits, budget, or materials). Observe the supplies available for this project. Brainstorm solutions and then choose one idea to develop and agree on a design for your irrigation system. Sketch and label the design. Select materials you will need to build a prototype based on your sketch. Test the prototype and determine what improvements are needed. Revise and re-test.

1. ASK / ENGAGE: Define the problem you are asked to solve, in the left block below.

2. IMAGINE/BRAINSTORM: What are some possible solutions to the problem that you are trying to solve? List ideas (in words) in the right block below.

3. PLAN/DESIGN: Share your ideas with your group and collaborate on a final design plan. Copy your team's final design plan below and identify which materials you will need to build it, choosing from the following list: dish pan, aquarium tubing, straws, tape, binder clips, paper clips, toothpicks, aluminum foil, jars or paper bowls.

DESIGN	Materials needed to build design

4. CREATE/TEST: Use your Final Design Plan to create and build your solution. Test your design to see if you can move two cups of water more than three feet away, into separate containers. Did it work? Why or Why not?

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5. EVAULATE/IMPROVE: Did your design work? (Did it move two cups of water at least three feet away from the source and distribute it equally into two containers? Was any water leaked or lost along the way?)

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How can you improve your design and make it work better? Draw and label your improved design below.

Name: ____________________ **Date:** ______________________ **School:** _______________________

STUDENT EVALUATION WORKSHEET

Use this worksheet to evaluate your team's results:

1. Did you succeed in creating an irrigation system that moved two cups of water at least one meter (three feet) and split the water equally into two separate destination containers? What was the best result (distance water traveled and amount collected in each destination container)?

2. If your system did not succeed, what do you think went wrong?

3. Which irrigation system design had the best results in your classroom?

4. How did you decide to revise your original design? What was the goal of this change?

5. If you had to do it all over again, what would you do differently? Why?

6. How would your design have had to change if the substance you were distributing was honey?

7. Do you think you would have been able to complete this project easier or more successfully if you were working alone? Explain your answer.

8. What forces were at work to move water in your irrigation system?

9. During a drought or water shortage, what gardening techniques could you use to minimize the amount of water needed to keep plants alive in the garden?

10. Identify a water ethics issue in which two people or groups have different ideas about fair use.

A Little Water Goes a Long Way

Grade: *6* | ***Time:*** *(3-5) 50 minute periods*

Name: ____________________ ***Date:*** ______________________ ***School:*** _______________________

Level of Mastery → **Benchmark or Performance Measure** ↓	 **Mastered task @ 80%+ proficiency 5 points**	 **Partially proficient 4 points**	 **Not yet proficient 1 point**	**TOTAL POINTS**
Irrigation Design Challenge	Completely Designed irrigation system that moved two cups of water for at least three feet and distributed it evenly in two separate containers.	Designed irrigation system that moved two cups of water for at least three feet but did not distributed it evenly in two separate containers.	Designed irrigation system that moved two cups of water but did not distribute at least three feet or evenly in two containers.	
Design, Re-design and Testing	Described 2 or more possible irrigation systems. Tested system design and re-design, including measurement of distance water traveled and amount of water loss.	Described 1 possible irrigation system and tested design including measurement of distance water traveled and amount of water loss.	Described a possible irrigation system and tested it but did not measure and record distance water traveled and amount of water loss.	
Water-moving forces	Identifies forces that move water (gravity, pressure or sunlight).	Identifies two forces that move water.	Identifies one force that moves water.	
Water conservation in the garden	Identifies 3 ways to conserve water in the garden (i.e. mulching to prevent evaporation, growing plants with similar water needs in same area; replacing non-native plants or grass with native species; correcting leaks; drip irrigation; hand-watering; collecting rainwater; watering at times that avoid evaporation, use of timers to prevent overwatering, etc.)	Identifies two ways to conserve water in the garden.	Identifies 1 way to conserve water in the garden.	
Ethics of Water Use	Identified an issue related to fair use of water	Discussed some water use issues	Unable to discuss water use issues	