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Lesson Focus

Lesson focuses on how through the centuries man has had the need to move water from one place to another. Engineered irrigation has proved critical throughout the world. Through this lesson, students work in teams to design and build a system to move water from one source to two different delivery areas. The challenge is to move two cups of water for at least three feet and distribute it evenly in two separate containers. They work with everyday items, develop a plan, build their "irrigation" system, and test their system. Students then evaluate the effectiveness of their own irrigation systems and those of other teams, and present their findings to the class.



Lesson Synopsis

The "Irrigation Ideas" lesson explores how civil engineering has solved the challenge of moving water via irrigation. Students work in teams of "engineers" to design and build their own "irrigation system" out of everyday items. They must move two cups of water at least three feet and result in a split of one cup of water in each of two containers. They test their irrigation systems, evaluate their results, and present findings to the class.

Age Levels

8-18.

Objectives

- ◆ Learn about civil engineering.
- ◆ Learn about engineering design.
- ◆ Learn about planning and construction.
- ◆ Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- ◆ civil engineering and design
- ◆ problem solving
- ◆ teamwork

Irrigation Ideas

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Lesson Activities

Students learn how irrigation systems move water from one location to others where it may be needed for farming or other purposes. Students work in teams to design and build an irrigation system out of everyday items, test their system, evaluate their own results and those of other students, and present their findings to the class.

Resources/Materials

- ◆ Teacher Resource Documents (attached)
- ◆ Student Worksheets (attached)
- ◆ Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ◆ TryEngineering (www.tryengineering.org)
- ◆ Land and Water Development Division of the Food and Agriculture Organization of the United Nations (<http://www.fao.org/land-water/land-water/en/>)
- ◆ Water Science for Schools - U.S. Geological Survey (<https://water.usgs.gov/edu/>)

Supplemental Reading

- ◆ Irrigation Engineering (ISBN: 1408626241)
- ◆ Irrigation: Its Principles And Practice As A Branch Of Engineering (ISBN: 1408626306)

Optional Writing Activity

- ◆ Write an essay or a paragraph about how irrigation is impacting life in South Africa, where "water poverty" is widespread. About a third of the country's 36 million people do not have adequate supplies of drinking water.

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For Teachers: Teacher Resource

◆ Lesson Goal

Lesson focuses on how through the centuries man has had the need to move water from one place to another. Engineered irrigation has had major impact on people all over the world. Through this lesson, students work in teams to design and build a system to move water from one source to two different delivery areas. The challenge is to move two cups of water for at least three feet and distribute it evenly in two separate containers. They work with everyday items, develop a plan, build their "irrigation" system, and test their system. Students then evaluate the effectiveness of their own irrigation systems and those of other teams, and present their findings to the class.

◆ Lesson Objectives

- ◆ Learn about civil engineering.
- ◆ Learn about engineering design.
- ◆ Learn about planning and construction.
- ◆ Learn about teamwork and working in groups.

◆ Materials

- ◆ Student Resource Sheet
- ◆ Student Worksheets
- ◆ Water basin and water for testing student irrigation systems
- ◆ One set of materials for each group of students:
 - Straws, cardboard or paper cups or bowls, clay, tubes, aluminum foil, rubber bands, tape, jars, toothpicks, glue, paperclips, plastic piping, tape, and other materials



◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students must work as a team to design an irrigation system to move two cups of water a distance of at least three feet. The team has a goal of splitting the water into two separate containers of exactly one cup each.
4. Students meet and develop a plan for their irrigation system. They draw their plan, and then present their plan to the class.
5. Student groups next execute their plans. They may need to rethink their design, or even start over.
6. Next....teams will test their irrigation system to see how it works. Students will measure how much water is gathered in each of the two destination containers and see how close their water is to the goal of one cup in each container. Student teams may test their systems three times and count the most successful test.
7. Teams then complete an evaluation/reflection worksheet, and present their findings to the class.

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For Teachers:
Teacher Resource (continued)**◆ Time Needed**

Two to three 45 minute sessions

◆ Tips

Teams may require additional materials which they will request of the teacher, or they may be encouraged to exchange building materials with other teams.

◆ Extension Ideas

- For older students, the challenge might be to split the water into three destination containers, or to adjust the ratio of water between the two destination containers to 75% and 25% instead of 50% and 50%.
- If more time is available, have the students consider making the most complicated irrigation system they can imagine -- along the lines of a Rube Goldberg machine. A Rube Goldberg machine performs a simple task in a complex way.
- Consider setting a budget for the project, assigning a cost to each material, and requiring teams to "buy" materials from the teacher to create their irrigation system.

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Student Resource: **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 for growing crops. Irrigation is frequently used 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 to 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, these 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 also is 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 baths and fountains. Water was then routed into the sewers, where they helped remove waste matter.



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Student Worksheet: **Ethical Implications**

Irrigation can route water to fields, help crops overcome drought, provide drinking water, and support waste removal.

But, how do engineers and others decide which use of water is the most important? What are the ethical considerations that must be reviewed to strike a balance of fairness?

For example, what if one farmer routed a river to serve his or her own crops and in doing so prevented his neighbors from receiving any river water?



Or, if water was routed to a company that stood to make a great deal of money from a profitable manufacturing facility, but in order to provide enough water for their process, all water would be diverted from small local farms farmers who might lose their livelihood. What would be fair?

Engineers are continually faced with ethical considerations when building structures, designing systems, and improving products.

Engineering does not have a single standard for ethical conduct because approaches vary somewhat by discipline. For example, a biomedical engineer might be concerned with respecting the feelings of a patient, or would want to pay particular attention to the reliability of a product such as an artificial heart. A civil engineer would consider safety and strive to develop a bridge that is not only safe, but also cost effective. A bridge could be over constructed, be safer than it would ever need to be, and be over budget as well.

◆**Question:**

1. 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?

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Student Worksheet:
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 three feet and split the water into two separate destination containers. If your system works, you'll end up with exactly one cup of water in each of your destination containers. How you accomplish the task is up to your team!

◆ Planning Stage

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your irrigation system. You have been provided with many items you may use to construct your system. As a team, come up with a plan, and draw your design in the box below. Be sure to indicate the materials you anticipate using. Present your design to the class. You may choose to revise your teams' plan after you receive feedback from class.



Materials Required:

Irrigation Ideas

Student Worksheet (continued):

4. Did you decide to revise your original design while in the construction phase? Why? How?

5. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?

6. If you had to do it all over again, how would your planned design change? Why?

7. How do you think your design would have had to change if the material you were distributing was honey?

8. Do you think you would have been able to complete this project easier if you were working alone? Explain...

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For Teachers:

Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (<http://www.nextgenscience.org/>)
- International Technology Education Association's Standards for Technological Literacy (<http://www.iteea.org/TAA/PDFs/xstnd.pdf>)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (<http://www.nctm.org/standards/content.aspx?id=16909>)
- U.S. Common Core State Standards for Mathematics (<http://www.corestandards.org/Math>)
- Computer Science Teachers Association K-12 Computer Science Standards (<http://csta.acm.org/Curriculum/sub/K12Standards.html>)

◆ National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- ◆ Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ◆ Abilities of technological design
- ◆ Understanding about science and technology
- ◆ Abilities to distinguish between natural objects and objects made by humans

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ◆ Types of resources
- ◆ Changes in environments
- ◆ Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ◆ Science as a human endeavor

◆ National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- ◆ Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- ◆ Abilities of technological design

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ◆ Populations, resources, and environments
- ◆ Risks and benefits
- ◆ Science and technology in society

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For Teachers:

Alignment to Curriculum Frameworks

◆ National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ◆ Science as a human endeavor

◆ National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry
- ◆ Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- ◆ Motions and forces
- ◆ Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ◆ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ◆ Personal and community health
- ◆ Natural resources
- ◆ Environmental quality
- ◆ Natural and human-induced hazards
- ◆ Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ◆ Science as a human endeavor
- ◆ Historical perspectives

◆ Next Generation Science Standards Grades 3-5 (Ages 8-11)

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- ◆ 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Engineering Design

Students who demonstrate understanding can:

- ◆ 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success/constraints on materials, time, or cost.
- ◆ 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ◆ 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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For Teachers:

Alignment to Curriculum Frameworks

◆ Next Generation Science Standards Grades 5-8 (Ages 11-14)

Earth and Human Activity

Students who demonstrate understanding can:

- ◆ MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

Engineering Design

Students who demonstrate understanding can:

- ◆ MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ◆ MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆ Next Generation Science Standards Grades 9-12 (Ages 14-18)

Engineering Design

Students who demonstrate understanding can:

- ◆ HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

◆ Standards for Technological Literacy - All Ages

The Nature of Technology

- ◆ Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- ◆ Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- ◆ Standard 5: Students will develop an understanding of the effects of technology on the environment.
- ◆ Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- ◆ Standard 9: Students will develop an understanding of engineering design.
- ◆ Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- ◆ Standard 11: Students will develop abilities to apply the design process.
- ◆ Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- ◆ Standard 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

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