Water Tower Challenge

Lesson Focus

Lesson focuses on water storage and how engineering helps communities preserve and supply water to populations. Students work in teams to design and build a water tower out of everyday materials that can "supply" and "shut off" water as needed. The system will need to deliver water in a controlled manner to a paper cup that is about 36 inches or 90 cm away in a controlled manner. They design their tower, build and test their system, evaluate their results, and share observations with their class.

Lesson Synopsis

The "Water Tower Challenge" lesson explores how engineers work to solve the challenges of a society, such as delivering safe drinking water. Students work in teams to devise a system using every day materials that can deliver water in a controlled manner to a paper cup that is about 36 inches or 90 cm away in a controlled manner. They sketch their plans, build their system, test it, reflect on the challenge, and present to their class.

Age Levels

8-18.

Objectives

- Learn about engineering design and redesign.
- Learn about water delivery systems.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

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

- engineering design
- water systems
- teamwork

Lesson Activities

Students explore how engineers have solved societal problems such as water delivery and storage. Students work in teams to develop a water tower out of everyday materials than can deliver water in a controlled manner to a paper cup. They evaluate their results, and the results of other teams, and share their reflections with the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Water Towers (www.watertowers.com)

Recommended Reading

- Water Towers (ISBN: 978-0262022774)
- Design for Water: Rainwater Harvesting, Stormwater Catchment, and Alternate Water Reuse (ISBN: 978-0865715806)

Optional Writing Activity

- Write an essay or a paragraph about environmental challenges to a water tower design. Consider how the weather, topography, the population of an area, or other factors might impact the design of a new water tower.

Optional Extension Activity

- Have students test their designs to see if they are scalable by doubling and tripling the distance from the water source to the cup.

For Teachers: Teacher Resource

Lesson Goal

The "Water Tower Challenge" lesson explores how engineers work to solve the challenges of a society, such as delivering safe drinking water. Students work in teams to devise a system using every day materials that can deliver water in a controlled manner to a paper cup that is about 36 inches or 90 cm away in a controlled manner. They sketch their plans, build their system, test it, reflect on the challenge, and present to their class.

Lesson Objectives

- Learn about engineering design and redesign.
- Learn about water delivery systems.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Materials

- Student Resource Sheets
- Student Worksheets
- Classroom Materials (water source, bucket or sink area)
- Student Team Materials: paper cups, straws, paper towels, rubber bands, paper clips, tape, balloons, soda bottle, glue, string, foil, plastic wrap, pens, pencils, paper, hose or tubes, siphon materials, paper towels, other items available in the classroom.

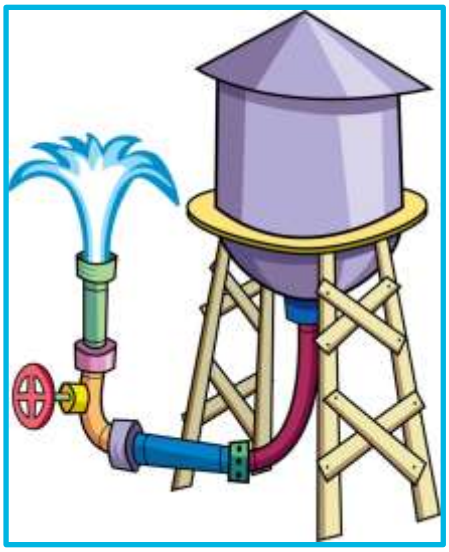
Procedure

1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students how water is supplied to their homes. Ask them to think about the buildings and systems required to deliver safe drinking water to their home.
3. Teams of 3-4 students will consider their challenge, and conduct research into how water towers operate.
4. Teams then consider available materials and develop a detailed drawing showing their water tower including a list of materials they will need to build it.
5. Students build their water tower, and test it, and also observe the systems developed and tested by other student teams.
6. Teams reflect on the challenge, and present their experiences to the class.

Time Needed

Two to three 45 minute sessions.

Student Resource:
Water Towers and Hydrostatic Pressure



◆ What is a Water Tower?

A water tower is a large elevated drinking water storage container that is engineered to safely hold a water supply at a height sufficient to pressurize a water distribution system. It needs to be big enough to supply residents of a community, or a building, with water, and also maintain the quality of the water that is stored and delivered. There are many designs for water towers all over the world. Some have become landmarks and are decorated whimsically. In certain areas, such as large cities, smaller water towers are constructed for individual buildings. Early water towers were often designed as part of a building. What does the one in your town look like?

◆ What is Hydrostatic Pressure?

Hydrostatic pressure is the pressure exerted by a fluid at equilibrium due to the force of gravity. It is the pressure of the water that forces water to flow through pipes into homes. If the pressure is not strong enough, water will not be delivered, or will be delivered too weakly to suffice for some applications such as fire hoses or showers. The higher the tank is and the larger the tank is, the more pressure and force that the water will have. Sometimes pumps are also used to push water through the water delivery system, especially at peak usage times. When engineers design a water tower, they know that every vertical foot adds .43 pounds per square inch to the water pressure. (Note: 1 psi equals 6,894.76 Pascals.) Most towns regulate water pressure at between fifty and one-hundred pounds per square inch, so a simple equation tells them how high to build the tower.

◆ Building a Water Tower

A wide range of materials are used to construct water towers -- including steel and reinforced concrete, with an interior coating to protect the water from any effects from the building material. The reservoir in the tower may be in many shapes, and they usually have a minimum height of approximately 6 metres (20 ft) and are a minimum of 4 m (13 ft) in diameter. Most water towers have a height of about 40 m (130 ft).The illustration to the right shows: 1. A pumping station to push water up int o the water, 2. A reservoir to hold the water, and 3. Examples of how the water might be used in a home, office, or apartment building.

Student Resource: All About Patents

What is a Patent?

A patent for an invention is the grant of a property right to the inventor, issued by a country's Patent and Trademark Office. The procedure for granting patents, the requirements placed on the patentee, and the extent of the exclusive rights vary widely between countries according to national laws and international agreements. In the United States, the term of a new patent is 20 years from the date on which the application for the patent was filed or, in special cases, from the date an earlier related application was filed, subject to the payment of maintenance fees. *Utility patents* protect useful processes, machines, articles of manufacture, and compositions of matter. Some examples: fiber optics, computer hardware, medications. *Design patents* guard the unauthorized use of new, original, and ornamental designs for articles of manufacture. The look of a specific athletic shoe or a bicycle helmet are protected by design patents. *Plant patents* are the way we protect invented or discovered asexually reproduced plant varieties. Hybrid tea roses, Silver Queen corn, and Better Boy tomatoes are all types of plant patents.

Famous Patents

Safety Pin: The patent for the "safety pin" was issued on April 10, 1849 to Walter Hunt, of New York. Hunt's pin was made from one piece of wire, which was coiled into a spring at one end and a separate clasp and point at the other end, allowing the point of the wire to be forced by the spring into the clasp.

Dishwasher: A patent for the first practical dish washing machine was issued December 28, 1886 to Josephine Garis Cochran of Shelbyville, Illinois. She was wealthy, entertained often, and wanted a machine that could wash dishes quickly, and without breaking them. When she couldn't find one, she built it herself.

How to Register a Patent

Each country, or sometimes a region has its own patent procedures. For example, in Europe, there is the European Patent Office; in the United States, the U.S. Patent and Trademark Office manages the patent process. Wherever you are, you have to design your product on paper or on a computer and specifically show why your design is different from others. On the left is one of the first drawings of the Coca Cola bottle, and on the right, is a copy of the patent design. You also need to check to see if someone else has already invented what you think you did! Try searching for a trademark at www.uspto.gov/patents.

Student Resource: Water Conservation

As you consider your town's water system, think about the many ways homes and businesses could conserve water and reduce the amount of water the town needs to provide. Here are several ideas:

Plumbing Modifications: install indoor plumbing fixtures that save water or replace existing plumbing equipment with equipment that uses less water. A good example is a Low-Flush Toilet that requires about a third of the water needed by conventional toilets. Another example is a Low-Flow Showerheads. Showers account for about 20 percent of total indoor water use and low flow heads use about half the water that conventional showerheads do. Or, consider installing faucet aerators which break the flowing water into fine droplets and mix air into the water while maintaining wetting effectiveness.

Lawn and landscape maintenance is an area where homes and businesses use large amounts of water, particularly in areas with low rainfall. One method of water conservation in landscaping is to select plants that need little water.

Changing Water Use Behaviors

There are many ways to save water in homes and businesses…here are a few ideas:

- Run the dishwasher only when it is full. If dishes are washed by hand, water can be saved by filling the sink or a dishpan with water rather than running the water continuously.
- Turning off the faucet while brushing teeth or shaving.
- Take shorter showers.
- In the laundry room, adjust water levels in the washing machine to match the size of the load. Or, only run the machine when it is full.
- If you must water a lawn, do it early in the morning or late in the evening and on cooler days, when possible, to reduce evaporation.

Student Worksheet:

◆ Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of developing your own water tower than can deliver water to a paper cup that is about 36 inches or 90 cm away in a controlled manner. This means you must be able to stop and start the flow and fill the cup up just half way. You'll be given a range of items to build with, but first with design your system on paper, then build it and test it. You'll reflect on the experience, and present your designs to your class.

◆ Research Phase

Read the materials provided to you by your teacher. If you have access to the internet, explore your town's water delivery system and see how engineers designed your local water tower.

◆ Planning and Design Phase

Engineers have built many different designs for water towers, but they all achieve the same goal of delivering water in a controlled manner to homes and businesses. Now it is your turn! In the space below or on a separate piece of paper, draw a detailed diagram showing the plan for your water tower.

Materials you will need:

Student Worksheet:

◆ **Presentation Phase**
Present your plan and drawing to the class, and consider the plans of other teams. You may wish to fine tune your own design.

◆ **Build it! Test it!**
Next build your tower and test it. You may share unused building materials with other teams, and trade materials too. Be sure to watch what other teams are doing and consider the aspects of different designs that might be an improvement on your team's plan.

◆ **Reflection**
Complete the reflection questions below:

1. How similar was your original design to the actual water tower your team built?

2. If you found you needed to make changes during the construction phase, describe why your team decided to make revisions.

3. Which water tower that another team made was the most interesting to you? Why?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. If you could have used one additional material (tape, glue, wood sticks, foil -- as examples) which would you choose and why?

6. Do you think your design is scalable? Would it work efficiently if the cup were 360 inches or 900 cm away from the water source? Why? Why not?

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
- Understanding about 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
- Position and motion of objects

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

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

- Types of resources
- 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
- Science and technology in society

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
- History of science

◆**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

CONTENT STANDARD B: Physical Science

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

- Motions and forces
- Conservation of energy and increase in disorder

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- 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
- 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 2-5 (Ages 7-11)**

Matter and its Interactions

Students who demonstrate understanding can:

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have properties that are best suited for an intended purpose.

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.

◆**Next Generation Science Standards Grades 2-5 (Ages 7-11)**

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 and 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.

For Teachers: Alignment to Curriculum Frameworks

◆Next Generation Science Standards Grades 2-5 (Ages 7-11)

Engineering Design

Students who demonstrate understanding can:

- 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.

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

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.

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope 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 6: Students will develop an understanding of the role of society in the development and use of technology.

Design

- Standard 8: Students will develop an understanding of the attributes of 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.