National Aeronautics and Space Administration

NASA eClips™

Educator Guide

NASA'S OUR WORLD

DESIGNING A SHOWER CLOCK

Educational Product	
Educators & Students	Grades 4-6

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Designing a Shower Clock

EDUCATOR GUIDE

National Standards:

National Science Education Standards (NSES)

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Science in Personal and Social Perspectives

- Science and technology in local challenges

International Technology Educator Association (ITEA)

Design

- Students will develop an understanding of the attributes of design.
- Students will develop an understanding of engineering design.
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

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Grade Level:
4-6

Subjects:
Environmental Science, Engineering Design

Teacher Preparation Time:
30-45 minutes

Lesson Duration:
three 55-minute lessons; some classes may require more time

Instructional Objectives:

Students will:

- work through the five steps of the Engineering Design Process to complete a team challenge.
- discuss various ways to conserve resources including ways to reduce, reuse and recycle.
- compare the water conservation methods they have discussed to those used by the scientists on the International Space Station.

Lesson Overview:

Students think and act like engineers and scientists as they follow the five steps of the Design Process to successfully complete a team challenge. Within this work, students design, measure, build, test, and re-design a shower clock. Once the shower clock is built, students discuss ways to conserve and recycle water. Students view a *Teaching from Space* NASA eClips video segment, then relate water conservation issues on the ISS to those in their daily lives.

Icons flag two areas of interest or opportunities for teachers.

- **Technology Icon** highlights opportunities to use technology to enhance the lesson.
- **Resources Icon** relates this lesson to other NASA educator resources that may supplement or extend the lesson.

Materials List:

Per student

- Design Process Packet
    - Elementary School Design Packet available at http://www.nasa.gov/pdf/324205main_Design_Packet_I.pdf

Per team of three

- (5) 235 – 355 mL (8 – 12 oz) plastic cups
- 1 m cotton string
- 1 thumbtack or pushpin
- 1 stop watch or timer
- 1 permanent marker
- 1 container for pouring water
- 1 plastic tub for catching water

Per class

- 1 hook for suspending clocks being tested
- 1 large basin for catching water

Recycled Water On-board the International Space Station

Nature has been recycling water on Earth for eons, and now NASA is doing the same thing above Earth on the International Space Station, or ISS. Two refrigerator-sized racks packed with a distiller and an assortment of filters have been delivered to the ISS. They are designed to process an astronaut's urine, sweat, and other waste water into clean drinking water.

Figure 1. NASA scientist Bob Badigan in front of the Water Recovery System used on the ISS. Image credit: NASA

Before the water recycler arrived on board the ISS, the station crew depended on water carried aboard space shuttles or cargo rockets. The water recycler has cut that need by 65 percent because it produces about 2,800 kilograms, or nearly 700 gallons, of potable (drinkable) water each year. That's enough fresh water to allow the station to host six crew members instead of three. The system on the ISS is testing the technology related to water recycling that will be necessary for future long-duration space exploration.

This new NASA recycler is the first water recycler flown in space that cleans and reuses almost all waste water a crew member produces. This system can recycle about 93 percent of the water it receives.

A major component of the water recycler is the distiller. On Earth, distilling is a simple process of boiling water and cooling the steam back into pure water. In the low-gravity environment of the ISS, the contaminants in water would never separate from the steam no matter how much heat is used. Therefore, the distiller is spun to simulate gravity. The contaminants in the water press against the sides of the drum while the steam gathers in the middle and is pumped to a filter.

The filter is similar to those used on Earth. It uses charcoal-like materials to pull other unwanted elements from the water. Another process uses chemical compounds that bond with the remaining contaminants the charcoal left behind so another filter can remove these chemicals from the water.

NASA's water filter development has also helped produce filters that are now used in humanitarian efforts on Earth to help provide clean water in areas served only by contaminated sources. This is just one example of NASA technology transferring into society. For more information about how NASA-developed technology is used in everyday life, visit http://www.nasa.gov/city.

5E Inquiry Lesson Development

ENGAGE – Brainstorm Water Use (25 minutes)

1. Ask students to brainstorm ways water is used in their daily lives. To continue the discussion, students may need to do some research about water use in the United States. (*Almost one-fourth of the water used each day is used in the bathroom. The flow of water from a showerhead ranges from 2.5 to 5.0 gallons per minute*.)
2. (**TECHNOLOGY**) Students may search the Internet for a water consumption calculator to find out how much water they use each day. A water calculator may be found on the United States Geological Survey website http://ga.water.usgs.gov/edu/sq3.html.
3. Ask students to estimate how long their showers last and to calculate the amount of water they use during a shower.
   a. Have students time how long their showers last the next time they take a shower.
   b. Shower heads produced after 1992 are limited to a flow rate of 8.33 L/min.
   c. To find the number of liters of water used, multiply 8.33 by the amount of time spent taking a shower.
   d. Note that older shower heads use more water and low-flow shower heads use less water. Teachers may wish to lead a class discussion about ways to reduce the amount of water used when taking a shower.
4. Ask students why water conservation is important. (*Answers may vary, but should include: water is a natural resource; water is essential to life; limited amounts of usable water are available on Earth, etc.*)
5. (**TECHNOLOGY**) Show the NASA eClips™ *Teaching from Space* video segment *Our World: Recycling on the International Space Station* (7:27) to the students. This segment can be found on the NASA eClips™ page of the NASA website: http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=recycling&category=1000.
   The video may be streamed or downloaded from the nasa.gov website; a captioned version is also available at the nasa.gov site. This video may also be streamed from the NASA eClips You Tube™ channel: http://www.youtube.com/nasaeclips#p/c/31002AD70975DC1B/12/2XIK5wXFQDY.
6. Emphasize to students that the video talks about three different ways to conserve water: recycling it, reusing it, and using less of it. Tell them that in this engineering design challenge they will be exploring a way to conserve water by using less of it.

EXPLORE – Design and Build Shower Clocks (90 minutes)

You will need the 8-page *Elementary School Design Packet* found at http://www.nasa.gov/pdf/324205main_Design_Packet_I.pdf for this section. Page 2 of the packet has a graphic of the engineering design process that you should review with your students. There is a student page for each of the design steps (Ask, Imagine, Build, Evaluate, Share) in the packet. The last page is a rubric you and your students can use to judge the quality of their work.

Inform students that their challenge is - or they are being "asked" - to use the engineering design process to solve this challenge:
Design and build a water clock that can be used to time a five-minute shower.

(**RESOUCES**) For more information about the engineering design process, visit the *Engineering is Elementary*® website http://www.mos.org/eie/.

1. **ASK**. Explain to your students that they will work as engineers in applying the design process. The first step in the design process is to ASK all the questions they can think of about the challenge. That will help them to understand what the end-product is supposed to do and what they need to do (or aren't allowed to do). However, innovative (clever and creative) solutions are welcome! Explain that in the ASK step students are identifying their limits (**criteria** and **constraints**) for the challenge. **Criteria** are conditions that must be met to solve the problem. **Constraints** are things that might limit the final solution, such as the cost or the types of materials they're allowed to use, or restrictions for safety.
2. As a class, ask students to create a list of questions related to the problem. Some questions students might ask include:
   a. What is a water clock?
      The basic concept behind the water clock is that a set time is required for water to flow from one container to another. Most water clocks consist of a system in which water drips from one elevated container into another.
      (**RESOURCES**) For more information about water clocks, visit the *Water Clock* page of the Children's Museum of Indianapolis website http://www.childrensmuseum.org/themuseum/icons/waterclock.htm.
   b. What materials are available?
      Give teams of 3 students the list of materials from page 2.
   c. Are there any limitations about how the clock is built?
      1. The water clock is being used to time a shower for five minutes.
      2. The clock must be able to be hung over a shower head.

        3. Each team must use a minimum of two cups and a maximum of five cups in their design.
    d. What are the guidelines that all teams must follow?
       Establish guidelines BEFORE students begin the challenge.
       Some suggested guidelines might be:
        1. Teams may request additional materials from the teacher.
        2. Students must work in teams to complete the challenge. Teams of three are suggested.
        3. Team roles may include:
            a. One person will be the Research/Design Specialist. This person leads the team to select the best design.
            b. A second person will be the Materials and Construction Specialist. This person leads the team in the construction of the water clock from several team-proposed solutions.
            c. The third person will be the Test Specialist. This person leads the testing process and records information from the test.
            d. Stress to students that although one person may be leading the team, all team members are expected to help design, build, and test the shower clock.
3. After the discussion, ask students to complete Step 1 on page 3 of the Design Packet to ensure that they understand the task.
4. Ask students to **Imagine** possible solutions. Students should complete step 2 on page 4 in the Design Packet, brainstorming solutions and choosing the best idea. Encourage the students to draw illustrations of their plans and use diagrams to explain their choices. Students may also record this work in a science notebook.
5. Use steps 3, 4A, 4B, and 4C on pages 5 - 6 of the Design Packet to guide students through the **Build** and **Evaluate** steps of the engineering design process.
6. Before students test their water clocks discuss and develop a set of rules, or criteria, for the testing process. Some rules might include:
    a. The clock will be suspended from a hook in the classroom.
    b. Once students add the water to the clock they are not allowed to touch the clock.
    c. Each team will have three trials of their clock.
    d. The Test Specialist for each team will keep the official time for each trial. The three individual times will be averaged and the average will be used to see how accurate the water clock is in measuring five minutes.
7. Provide ample time for students to test and change their water clocks. After each test, students should record observations and make notes about their

clock adjustments and modifications. Students should record observations and notes in a table of their own design.

8. (**TECHNOLOGY**) If digital cameras are available, ask students to take several pictures to document the design/build/test process.

EXPLAIN - Compare Clock Designs and Results (10 minutes)

1. Ask students to discuss and compare the design and operation of their water clocks, and how they might help conserve water. These questions may help guide the discussion:
   - What causes the water to flow from one cup to another? (*Gravity causes the water to flow downward*.)
   - What is the effect of having different hole sizes in the cups? (*The size of the holes changes the amount of water required to time five minutes. The larger the hole, the more water is required*.)
   - Would the water clock work on board the ISS? Why or why not? (*The water clock would not work on board the ISS. The force of gravity there is so weak that the water would not flow from one cup to another*.)

EXTEND- Redesign Clocks (20 minutes)

1. Guide students to think about changes they might include in a new version of a water clock. What other materials might they use? Why would they make the changes? Ask students to complete steps 4D, 4E, and 4F on page 6 of the Design Packet to complete the **Evaluate** portion of the design process.
2. If time permits, allow the students to build and test their improved designs. (*This assignment could be given to the students to complete outside of class or could be used as a way to involve families in this design challenge*.)

EVALUATE (20 minutes)

1. For formative assessment, review student entries for each step in the design process before proceeding to the next step. For example, the teacher could review the **Imagine** entries before students proceed to the **Build** step.
2. Guide students to complete the final step of the design process found on page 7 of the Design Packet, Step 5: **Share**.
3. (**TECHNOLOGY**) Encourage students to use digital resources such as digital cameras and multimedia presentation software to help explain their ideas.
4. Have students submit their design logs/notebooks and use the Design Challenge Evaluation Rubric on page 8 of the Design Packet to evaluate student understanding of the design process.
5. Ask students to explain how their water clocks could help conserve water

while taking a shower. (*Since the water clock does not require electricity, it can be hung in a shower. People taking a shower can easily see when five minutes are up. Taking a five minute shower would use less water than taking a longer shower.*)

ADDITIONAL RESOURCES:

About the *Teaching from Space* Program

Imagine speaking live with crewmembers orbiting Earth on the International Space Station (ISS) or using real NASA equipment to test student experiments. NASA's Teaching from Space offers unique resources and opportunities that give you the tools to launch students into a deeper understanding of science, technology, engineering, and mathematics (STEM). The opportunities listed below, and so many more, are available to you and your students!

- Live in-flight education downlinks – Students have a conversation with astronauts and cosmonauts living on the ISS.
- ISS EarthKAM – Students direct a camera onboard the ISS to take photographs of Earth.
- Themed websites – One stop shopping for education resources related to spacesuits, robotics, and rockets.
- Access to NASA experts and unique facilities – Student challenges and experiments that provide hands-on learning and interaction with NASA scientists and engineers.
- Amateur Radio on the ISS (ARISS) – Students use ham radio to connect with the International Space Station.
- "Day in the Life" website – Follow astronauts on the ISS in a series of videos as they explain their daily routines.

Visit the *Teaching from Space* Web site at http://www.nasa.gov/education/tfs.