

Activity 5:

Low-Tech Water Filter for High-Impact Clean

Overview

Participants consider the water features they might enjoy at a community park — a pond, brook, water playground (or “sprayground”), or pool, — and what happens to the water over time. In small groups, they explore and test common materials to identify the best low-tech materials that can be used to help filter water.

Activity Time:

20 to 30 minutes

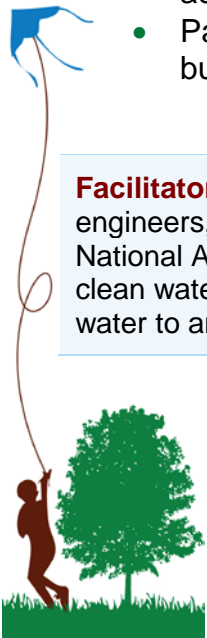
Intended Audience:

Families or other mixed-age groups, including children ages 5–7
Tweens up to about age 14

What’s the Point?

- Access to clean water is just as important at a community park as it is at home and in communities around the world.
- To get water clean, contaminants like dirt, leaves, insects, algae, and zooplankton (and even microscopic components, like bacteria and chemicals) must be removed.
- Engineers use technology — including everyday materials, such as sand, gravel, activated charcoal, and cloth — to provide people with clean water.
- Participating children, tweens, and adults, like engineers, can identify low-tech building, testing . . . and doing it again!

Facilitator’s Note: Young participants in this activity are potentially the next generation of engineers, and those engineers will face an array of pressing challenges identified by the National Academy of Engineering as Grand Challenges for Engineering. “Provide access to clean water” is one of those challenges. Engineers of the 21st century must work to supply water to areas that need it and develop technologies for cleaning water for human use.



Materials

For the Facilitator

- Implementation Guide* (available at www.starnetlibraries.org), which includes:
 - Playful Building's* key features
 - Annotated facilitation outline
 - Facilitator background information
 - Shopping list
 - Extended supporting media suggestions
 - Correlations to National Science Education Standards
 - Contact information
 - STAR_Net project overview
 - Credits and acknowledgments
- Brief Facilitation Outline* page
- Playful Building* PowerPoint presentation (or the instruction slides printed for the groups to use) (available at www.starnetlibraries.org)
- 1 fine-tipped permanent marker
- 1 ruler or measuring cup

Facility Needs

- Access to water for cleaning containers during the activity
- Access to 3–4 rolls of paper towels
- Access to one or more trash receptacles
- 1–2 tables, covered in disposable tablecloths
- Optional: computer, speakers, projector, projection screen, and access to the Internet
- Optional: a writing surface where the groups may sketch and write, such as:

<input type="checkbox"/> 1 white board	AND	<input type="checkbox"/> 4–8 dry-erase or other appropriate low- or no-odor markers
OR		
<input type="checkbox"/> 2–4 (~36" x 48") pieces of butcher paper, posted on the wall or used to cover the tables		OR
		<input type="checkbox"/> 4–8 crayons
OR		
<input type="checkbox"/> 5 or more sheets of poster paper		
- Access to an outdoor area to dry and reuse or dump several types of garden-safe materials after the activity



For an Audience of 15-20 to Share

- 5–6 (2-L) empty, *clear plastic* water bottles with the label and cap removed (preferably cleaned and repurposed for this activity)
- 1 (16-oz. or larger) clear plastic container, such as a measuring cup
- 1–2 (36" × 3 yards) packages of cheesecloth, purchased from a supermarket or kitchenware store
- 10 rubber bands

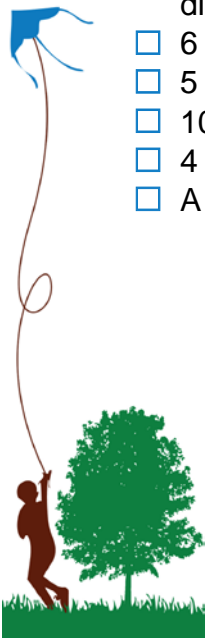
Substitutions: Each family or group needs to have a funnel-shaped container to hold filtration material and a *see-through* container to catch the water coming out of it. Plastic bottles in 2-liter, 16-oz., or 8-oz. sizes can be cut into these containers. (Note that the demonstration filter should be a 2-liter bottle.) Or, the following substitutions can be made:

- To hold the filtration material:
 - 1 wide-mouthed (“canning”) funnel (purchased from a retailer such as [Amazon.com](https://www.amazon.com))
 - 1 metal mesh, reusable coffee filter (purchased from a retailer such as [Amazon.com](https://www.amazon.com))
- To catch the water:
 - 1 (16-oz. or larger) clear plastic cup
 - 1 (1- or 2-cup) clear plastic or glass measuring cup

Ensure that the funnels will rest on the tops of the containers. The mouths of the funnels should not be submerged when the containers fill with about one teaspoon of filtered water.

- Can't find cheesecloth? Use a nylon stocking instead.

- 10 or more (~10" × 5") pieces of silk and/or cotton knit fabric, such as clean, discarded clothing or scraps from a fabric store
- 6 cups of play sand
- 5 cups of *small* aquarium gravel
- 10 (~1") chunks of lava rock
- 4 cups activated carbon/charcoal (sold at aquarium supply stores)
- A selection of additional filtration materials to choose from, such as:
 - 1 cup of rice
 - 30 (5/8") marbles
 - 30 (non-biodegradable/dissolvable) Styrofoam peanuts or “popcorn” (preferably reused from a shipment)
 - 10 (1" × 1") pieces of synthetic sponge
 - 1 package of cotton balls

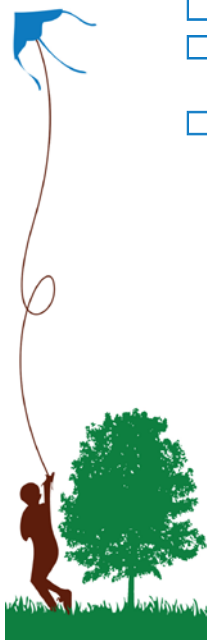


- 10 (5" × 5") pieces of quilt batting
- 2 cups paper, shredded into strips or torn into ~½" pieces
- 10 coffee filters
- 1 batch of "dirty water" created with:
 - ~2 teaspoons of tea leaves (or the contents of 3–4 tea bags)
 - 3 cups boiling hot water
 - 1 (1-quart) tea pot or Pyrex measuring cup
 - 2 or more (~1-cup) containers for holding and pouring "dirty water," such as measuring cups (preferably with spouts for easy pouring) or clean, empty personal water bottles
- AND 2 or more labels or pieces of masking tape

Substitutions/alternatives for "dirty water:"

- A mixture of water and flour.
- A mixture of water, blue or red food coloring, and oil is especially effective when filtered through sand. The oil will be trapped in the sand, and colored water will be collected in the container.
- If the activity is conducted outdoors where messiness can be encouraged, consider using dirt (not potting soil) with water instead of the tea.
- Conduct the "Who Dirtied the Water?" activity recommended in the extensions section first, and filter the "polluted" water.

- 6 teaspoons or medicine droppers (for adding "dirty water" to the filters in small amounts)
- 6 empty jars, pitchers, or other containers for collecting filtered water for later disposal
- Optional: microscope, microscope slides, and water samples collected from a park fountain, stream, pond, or lake
- 15–20 aprons or trash bags to wear over clothing
- Safety signs, which read "Be safe! Do not drink this water"
- 1 (8½" × 11") *Be Creative...Be an Engineer!* poster (for tweens, teens, and adults)
- Optional: 1 (8½" × 11") *Grand Challenges of Engineering* poster (for teens and adults)



Supporting Media

A more extensive list is included in the *Implementation Guide*.

There are opportunities to display videos, images, podcasts, or websites before, during, or after the activity.

Online Resources

“Milena Boniolo — Using bananas to clean water in Brazil,” **TEDFellowsTalks**, Sep. 2, 2010

www.youtube.com/watch?v=RTS0l3m2kg

“Fruity Filter,” **The Loh Down On Science** radio program

staging.scprdev.org/programs/loh-down-on-science/2011/06/27/25202/fruity-filter/

Engineer Your Life: Environmental Engineer Daniele Lantagne

www.engineeryourlife.org

This guide to engineering offers videos, photos, career stories, and personal “tidbits” for each of 12 engineering professionals. For example, Daniele Lantagne works as an environmental engineer at the Centers for Disease Control and Prevention (CDC), where she travels the world to help communities access clean drinking water. Appropriate for ages 8 and up.

EWB Thailand 2011

www.youtube.com/watch?v=JAclIHct3aA

Engineers Without Borders student volunteers installed slow sand filters to supply clean water to villages in Thailand.

Grand Challenges for Engineering

www.nae.edu/Activities/Projects/grand-challenges-project/Videos_grandchallenges.aspx

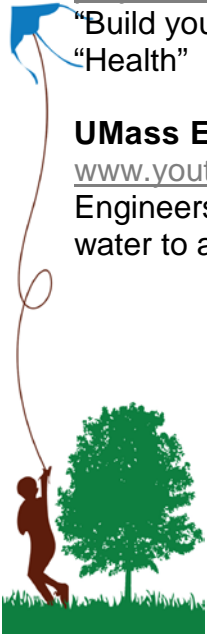
“Build your Dream”

“Health”

UMass Engineers Without Borders Head to Kenya

www.youtube.com/watch?v=AmOJd6LyaMA

Engineers Without Borders student volunteers installed a well to supply clean drinking water to a Kenyan village.



Books

Making Water Clean

Rebecca Olien, Capstone Press, 2006, ISBN 9780736851787

The photographs and clear text in this book explore water as rain, in lakes and rivers, and from the tap. Appropriate for ages 6–9.

Clean Water (Sally Ride Science)

Beth Geiger, Flash Point, 2009, ISBN 9781596435773

Photographs, illustrations, and examples from countries throughout the world are used to highlight some developing technologies for recycling and desalinating water. Appropriate for ages 8–12.

Cool Engineering Activities for Girls

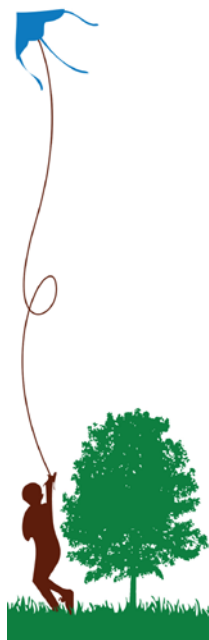
Heather Schwartz, Capstone Press, 2012, ISBN 9781429676779

Photographs depict girls undertaking nine different projects, including a water filter and solar cooker. Step-by-step instructions are provided. Appropriate for ages 8–14.

Janice VanCleave's Engineering for Every Kid: Easy Activities That Make Learning Science Fun

Janice VanCleave, Jossey-Bass, 2007, ISBN 9780471471820

VanCleave provides background information, exercises, and hands-on activities for each of 25 different engineering topics. Topics include Push and Pull: Structural Engineering, Coming Through: Solar Engineering, and Around and Around: Hydrology Engineering. Appropriate for ages 8–12.



Preparation and Cleanup Tips

Before the day of the activity

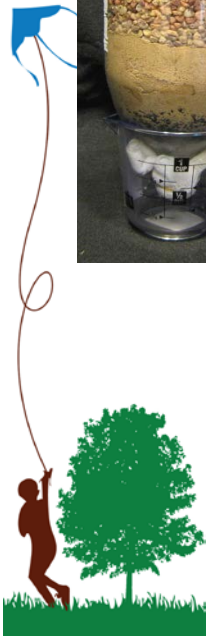
- Use the *Implementation Guide* to determine the setup of your engineering program(s), organize and prepare your presentation, and help you collect the materials.
- Prepare publicity materials for these or any other future engineering and technology programs.
- Incorporate the *Playful Building* PowerPoint presentation into your facilitation plan. Modify the presentation to suit your needs.
- Collect and prepare materials.
 - Clean recycled containers using a diluted bleach solution.
 - Construct one or more demonstration water filtering systems:

Facilitator's Note: These portions of materials from the above list are intended to be used for the demonstration system:

- 1 (2-liter) bottle
- 1 (16-oz. or larger) clear plastic container, such as a measuring cup
- 6 or more (5" x 5") layers of cheesecloth
- 1 rubber band
- 3 cups of play sand
- 2 cups of small aquarium gravel or 3–4 (~1") pieces of lava rock
- 1 cup activated carbon/charcoal



- Cut off the base of the bottle, just above the curve of the bottle.
- Cover the mouth of the bottle with six or more layers of cheesecloth and use a rubber band to secure them.
- Balance the bottle, upside down, in the measuring cup (careful! It can tip easily!). Make sure the mouth of the bottle will not be submerged when the measuring cup fills with about a cup of filtered water.
- Add 1 cup of activated carbon/charcoal [or up to a depth of about 2–3 inches (5–8 cm)].
- Add 3 cups of play sand [or up to a depth of about 3–4 inches (8–10 cm)].
- Add 2 cups of gravel [or up to a depth of about 2–3 inches (5–8 cm)]. (Small chunks of lava rock may be used instead.)



- Create funnels and containers for the groups to use by cutting the upper 1/4 to 1/3 off each bottle. Invert the top portion of the bottles into the bottoms.

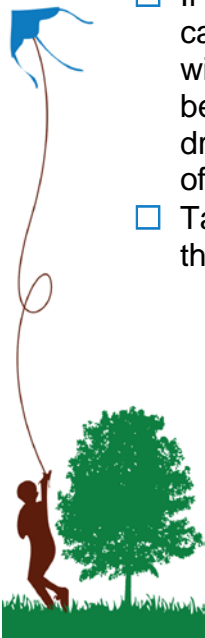


The day of the activity

- Set up the facility.
- Set out the materials.
- Print the *Brief Facilitation Outline* page, which integrates the steps of the activity with the annotated facilitation outline presented in the *Implementation Guide*, to use as presentation notes.
- Provide access to any supporting media and the *Playful Building* PowerPoint presentation (or printed copies of the instructions slides for this activity).
- Set out the safety signs, *Grand Challenges* page, and the *Be Creative* poster (or hang them on a nearby wall).
- About 45 minutes or more before the start of the activity, begin preparing a batch of “dirty” water by steeping loose tea leaves in hot water. Use caution when preparing the hot tea. Allow the tea to cool. Reserve one cup of “dirty” water to use with the demonstration filter. Provide the remaining tea alongside the other materials, separated into at least two containers, and label it as “dirty water.”

Cleanup

- If diluted tea is used to represent “dirty water,” the sand, gravel, and activated carbon can be rinsed, dried, and reused after the activity. (Note that reused sand will compact; loosen and wet it before using it for filtering again.) They can also be disposed of in a garden (a “green” alternative to pouring the tea down the drain). Diluted tea may be beneficial to plants; the “dirty water” can be disposed of in a garden or lawn.
- Take extra care in disposing of “dirty water” and used filters that involve foods, as they may attract pests.



Activity

1. Ask questions about the kinds of water features the participants enjoy at parks — and what happens to the water over time — to facilitate a conversation about the following points:
 - Ponds, water playgrounds (or “spraygrounds”), and pools are fun ways to enjoy water at community parks.
 - Water features at parks become dirty.
 - Dirt and leaves from trees and plants will blow into the water.
 - Algae and bacteria may grow in the water.
 - Chemicals — like pesticides — may run off into the water during rainstorms.
 - These must be removed to keep people from getting sick.

Facilitator’s Note: While supplying clean water to a community park is certainly important, not everyone has access to clean water for their basic needs. Many communities around the world need better access to clean water.

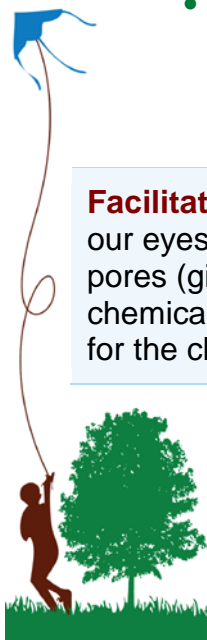
If teens and/or adults are present, offer the *Grand Challenges of Engineering: Provide access to clean water* page as a source of further information.

2. Use the demonstration water filtering system to show everyone how layers of several different — simple — materials can be used to clean water.

Facilitator’s Note: If the flow of water slows in the demonstration system, *lightly* press the sides of the bottle to shift the contents.

- Pour about 1 cup (225 mL) of “dirty water” into the top of the demonstration system.
- Ask the groups to watch the “dirty water” *slowly* filter through layers of rock, charcoal, and sand in the demonstration filtration system. Point out how tea leaves become trapped in the layers. Note that it takes a while for the water to go through each layer and flow out to collect in the cup.

Facilitator’s Note: Activated charcoal helps clean water in ways that are invisible to our eyes. Activated charcoal has been treated with oxygen to open up millions of tiny pores (giving it a much larger surface area than untreated charcoal). Certain kinds of chemicals “stick” (or adsorb) to charcoal, and the millions of pores provide many places for the chemicals to “latch on” and be removed from the water.



- Optional: While waiting for the water to filter, either begin the testing in groups or use the supporting media to explore how engineers are creating water filters.
- After about 1/4 cup or more of water has trickled through — perhaps after the participants have begun the next steps — compare it to the color of the “dirty” water.
- If desired, pour the water through the demonstration filter multiple times and continue to compare its color to the “dirty water.”

Facilitator’s Note: The groups may be disappointed that the “dirty water” did not come out clear, but only subtly lighter in color. Point out how easy it is to add things to the water . . . and how difficult it is to remove them again! If desired, have a discussion about the implications of using our freshwater sources to transport sewage and industrial waste.

3. Challenge the participants, working in groups, to do their own tests with sand, gravel, activated charcoal, and cloth to see which would be good to use for filtering water at their imagined community park. Caution everyone not to drink the water from their filters! Allow time for questions.
4. Break into groups (with three to four people each) and begin. Encourage each family to work together as a group — parents too!
5. Guide the children through the engineering design process as they work. Encourage groups to methodically test one material at a time.

Facilitator’s Note: As time allows, have the groups change one thing at a time after each test. Adjusting and retesting ideas is the best way to experience the ongoing work of an engineer!

Reassure the participants that there isn’t a “right” answer that they must arrive at on the first try. Furthermore, failure is an essential part of figuring out what works and what doesn’t. It is OK to fail — and try again . . . and again . . . and again!

6. Optional: While the participants wait for the water to filter through their funnels, use the supporting media to explore how engineers are creating water filters.
7. Optional: Have each group present their most effective filter to the entire audience.



Extensions

Optional: The most successful filtering systems involve several layers of different materials to remove dirt, oil, salt, or other unwanted contaminants. However, it takes additional time for the water to travel through multiple layers. Extend this activity — perhaps by leaving the participants' filtering systems overnight. Build and test a water filtration system made up of layers of the materials that the group found to be most effective at cleaning water. Challenge the participants to switch the order of the materials: Which material works best on top? In the middle? At the bottom?

Additional Activities

Allow additional time, per the instructions provided on these external websites, if incorporating these activities.

“Who Dirtied the Water?,” Museum of Science and Industry

www.msichicago.org/fileadmin/Education/learninglabs/lab_downloads/TTW_dirtied_the_water_act.pdf

Children are read the story of an imaginary place, where the activities of wildlife and people influence the area's lake. At a key point in the story, each child adds a “pollutant” to the “lake” — usually eliciting an “ewwww!” from the audience! An aquarium or other large container is used to simulate the lake, and common materials like paper, vinegar, and molasses represent the pollutants. The story is used to start a conversation about pollution in our lakes, rivers, oceans, and groundwater. Appropriate for ages 8–13.

“Water Filtration using Fabric,” Instructables web-based documentation platform

Posted under username “Danger is my middle name.”

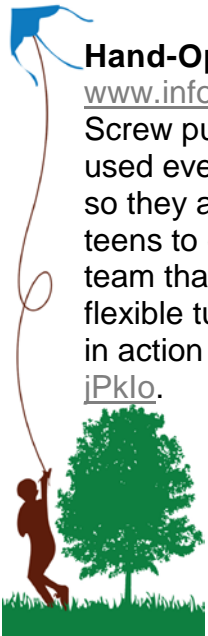
www.instructables.com/id/Water-Filtration-using-Fabric/

This investigation was originally conducted at the college level, but it could be modified for use with children and teens. To conduct the turbidity measurements suggested in the procedure, consider using a transparency tube purchased from a science education supplier, such as WARD's Natural Science (<http://wardsci.com>).

Hand-Operated Water Pump (Archimedes' Screw)

www.informit.com/articles/article.aspx?p=413663&seqNum=4

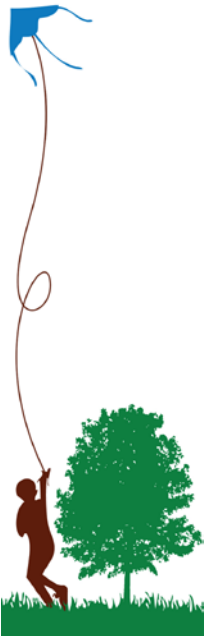
Screw pumps — similar to that allegedly invented by the Greek scientist Archimedes — are used even today. The design of the screws is open enough to permit debris to pass through, so they are used to pump sewage in wastewater treatment plants. Challenge tweens and teens to create and test a working screw pump — perhaps to lift “dirty water” up to a second team that is constructing a water filtration system. Water or a small ball can be lifted through flexible tubing wrapped into a spiral, as detailed by this hands-on activity. View a screw pump in action at “Archimedes Screw,” www.youtube.com/watch?feature=fvwp&NR=1&v=kz8Ct-jPklo.



References

This activity was inspired by the following educational materials:

Activity adapted from *Cleaning Water*, a NASA educational activity, www.nasa.gov/pdf/146846main_Cleaning_Water_Educator.pdf.



Brief Facilitation Outline

Introduction

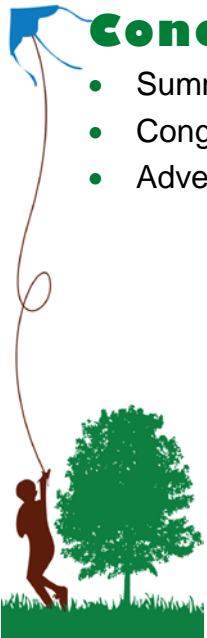
- Introduce yourself and the library.
- Frame the activity with the main message: Engineers work to solve the basic challenges of life — including having fun!
- Conversation:
 - Ask open-ended questions about things we need for *enjoyment* in life.
 - Discuss examples of how engineers use (simple) technologies to improve lives, e.g., using cloth or systems built from rocks and reeds as water filters to help prevent diseases in underdeveloped countries.
- Encourage persistence: Successful engineering involves a process of thinking, building, testing . . . and doing it again!

Activity

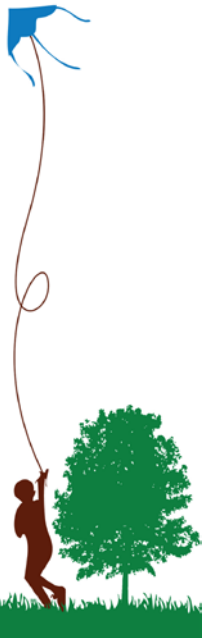
- Conversation: Ask questions about the kinds of water features the participants enjoy at parks — and how dirt, leaves, algae, bacteria, and chemicals must be removed to keep people from getting sick.
- Demo: Show how layers of several different materials can be used to clean water.
- Challenge (in groups of 3–4; parents too!): Test sand, gravel, activated charcoal, and cloth to see which would be good to use for filtering water.
 - Caution everyone not to drink the water from their filters!
- Emphasize the engineering design process; encourage groups to methodically test one material at a time.
- Use supporting media to explore how engineers are creating water filters (optional).
- Present the most effective filters (optional).

Conclusion

- Summarize the groups' explorations of how engineers solve life's challenges.
- Congratulate the groups on their accomplishments.
- Advertise any future engineering and technology events.



Activity Materials to Print

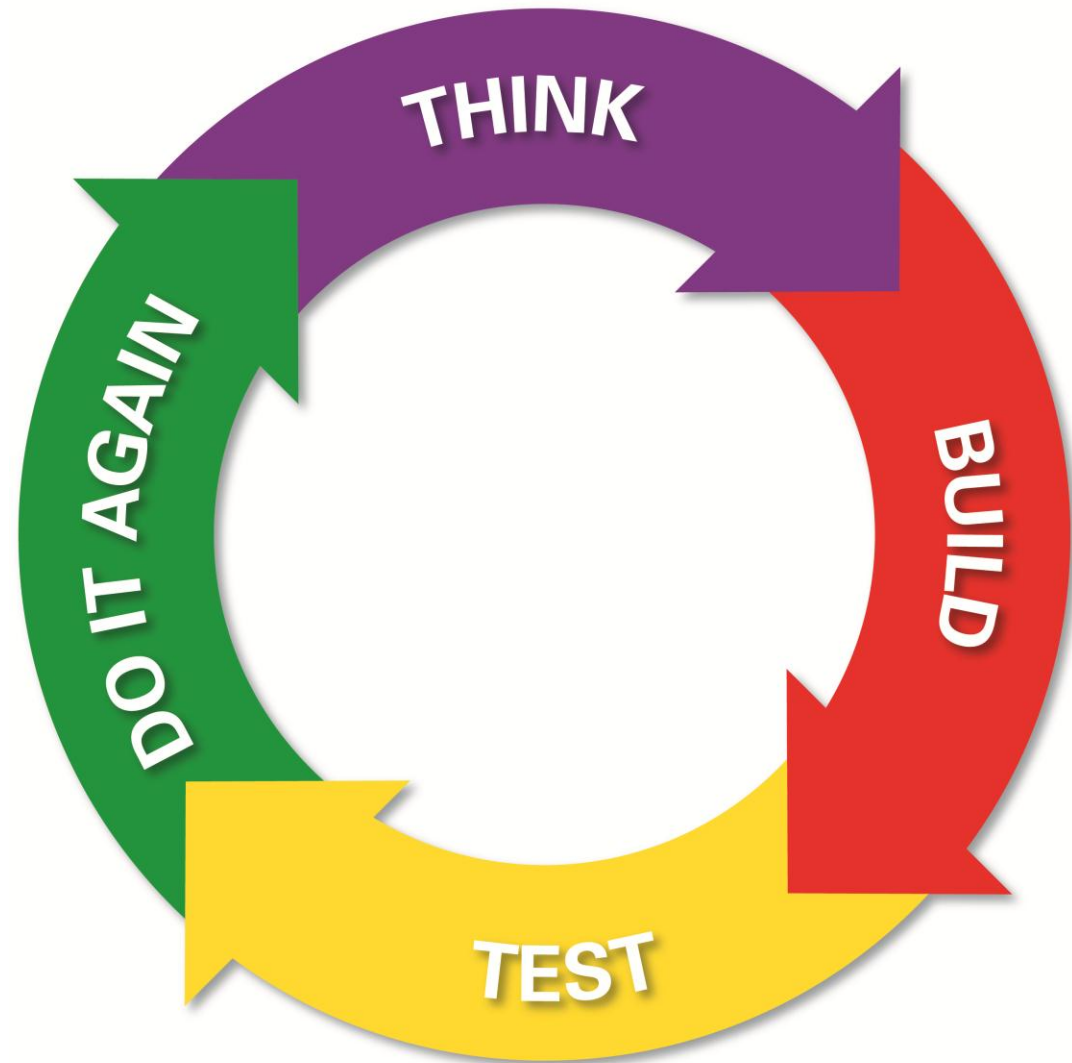


Be Creative...Be an Engineer!

Think, build, test, do it again: That's the process engineers use when they tackle a problem. Engineers don't have official rules telling them to follow this set of steps. But, over time they've learned that they get the best results this way:

They think and brainstorm about a problem and factors they have to consider to solve it. They come up with an idea and build a prototype. They test the prototype. And, then they repeat the process to improve their results.

Engineers often move back and forth within the loop, repeating two steps over and over again before moving forward. It's a key to engineering success.



Provide Access to Clean Water



This GRAND CHALLENGE encourages engineers to **find ways to provide all people on Earth with access to clean water.**

One in six people in the world don't have sufficient access to clean water for drinking, sanitation, and agriculture. To meet this challenge, engineers **need to find ways to transport water** from areas where it is abundant to remote communities where it is not. They must also develop **effective systems for cleaning contaminated water.**

Restore and Improve Urban Infrastructure



This GRAND CHALLENGE encourages engineers to **improve aging roads, railways, water facilities, sewage treatment, and other city systems.**

Urban infrastructures have been crumbling for decades. The problem is especially acute in Asia, home to the world's largest cities. Engineers must find **environmentally safe ways to modernize outdated and inadequate city support systems.** Billions of people's health, safety, and quality of life depend on it.