MESA Advisor Facilitator Guide

Water Filtration

Introductory Activities

These fun activities are meant to be used during the first 1-3 MESA sessions, while students are still getting to know each other and getting to know MESA. Choose the ones you like.

Water Filtration

The following is the suggested order of activities for advisors who choose to focus on the Water Filtration problem. Your goal is to finish these activities by the end of December!

A. Students will participate in the "If the World Were a Classroom" activity to help them understand how many people do not have access to clean water, shelter, etc.
B. Students will watch the following videos to gain a better understanding of the issues surrounding water, sanitation, and disease.
   Video Links: "Shared Water Source-Clip of the Day" (51 sec)
   http://www.youtube.com/watch?v=HidSH2Ntmj0
   "Waste in Water-Clip of the Day" (18 sec)
   http://www.youtube.com/user/water#p/u/7/ajhUotHKhio
C. Lastly, students will make edible aquifers as a tasty way to introduce the geologic formation of an aquifer and how contaminants can affect drinking water.

A. In this lesson, students should be introduced to common Waterborne diseases. The Peace Corps Lesson – Water: Source of Health, Source of Illness is a good source of this information. Additionally, there are many videos and websites that contain similar information. However you choose to present the information, you can use the Waterborne Illness Research Chart as a place for students to record their learning.
B. If there is time, try the SCAMPER activity to introduce students to the Engineering Design Process.

For students to be successful in collecting data on how well their water filter functions, they need to understand a bit about turbidity and pH. Advisors should consider trying to teach both concepts during the same after school session.

A. The EPA Turbidity Lesson
B. Discovery School Acids and Bases Lesson

Students will gain a better understanding of the "clients". For this project: the people who are in need of access to clean water.

A. Have students complete the Meet the Client sheet based on the "Clean Water for Haiti" video
   Video Link: http://www.youtube.com/watch?v=LPAWuws7qMM (5:38 sec)
B. Present students with the design brief. The design brief will explain exactly what is expected of their Water Filtration Invention and how it will be measured. Over the next few weeks, students will fill in the remaining components on the Design Brief.

Based on what they know about their client and the design restrictions, students will go through the Engineering Design Process to create a product to filter water.

Extras (these are posted on the MESA website):

- EPA Virtual Tour of Drinking Water Treatment Plant
- EPA lesson – What is in source water?
  EPA Lesson – Water Filtration

Presentation of Inventions

The following activities will help students prepare poster boards to showcase their inventions. Ideally, your MESA chapter will hold an Invention Family Night by the end of January!

Students create a poster board that outlines their Water Transportation/Filtration Invention.

Students Water Transportation/Filtration Inventions and poster board displays are shared with their families.

Appendix

Rube Goldberg and the Engineering Design Process

Goal

- Students will be introduced to the **Engineering Design Process** by creating a Rube Goldberg Machine to solve a problem.
- Students will become familiar with using their **design notebooks**.

Outcome

- Students will be able to compare the steps they took in creating their Rube Goldberg Device with the **Engineering Design Process**.
- Students will use their **design notebooks** to record information

Description

In this activity, students will cut out and glue the **Engineering Design Process** in their **Design Notebook**. Then, they will build a Rube Goldberg Machine that will perform a specific task. Students will construct their machine out of common items, test it, and present their results to the rest of the class.

Time

This activity is expected to take 2 full sessions.

Supplies

- A MESA Journal for every student
- Glue
- Scissors
- Handout: Your Design Notebook
- A Variety of odds and ends that students can use to build a simple machine (i.e. paper towel rolls, marbles, bearings, tape, glue, books, dominoes, scissors, markers, plastic tubing, pieces of wood, paper clips, etc)
- If using the buzzer/light kit: Tin Foil
- An internet connection, projector and screen or a DVD player/TV

Preparation

Before meeting:

- Read through the Rube Goldberg handout for students
- Copy handouts – 1 for each student
- Collect random materials in addition to those in the kit with which students can build their machines
- Optional: make your own Rube Goldberg Machine to show the students

Meeting day:

- Place boxes of materials around the room
- If using the buzzer/light kits, be sure to have them ready by having foil "pads" surrounding each wire connection so that all students have to do is touch the two sheets of foil together to make the buzzer/light go off
- Have an internet-ready computer and projector ready, or a DVD player

Procedure – EDP Handout

1. Give each student a copy of the **Engineering Design Process (EDP)** handout and a notebook.
2. Have students cut out the **Design Notebook** directions and glue it to the 3rd or 4th page of their new notebook. Go over the directions.
3. Have students cut out the box with the **Engineering Design Process (EDP)** and glue it to one of the first pages in their notebook. Go over the process with them. You may want to have them take turns reading the EDP aloud.
4. Move into Building a Rube Goldberg Device

Procedure – Rube Goldberg

1. Start by introducing the lesson and posing a question to students: What is engineering design? Brainstorm that engineering design is a process whereby people come up with solutions to practical problems or improve on existing designs.
2. Hand out the activity sheet. Introduce the concept of a Rube Goldberg Machine to students: a "machine" that performs a (usually) simple task through a complicated series of steps. Read the background information out loud as a group and examine the cartoon. Explain that students are going to build a Rube Goldberg Machine after watching a video (or two) for inspiration.
3. Watch some Rube Goldberg videos. Recommended Video: The Honda commercial (see references for URL's and other Rube Goldberg Links). After each video, have students identify the specific task that each machine was designed to accomplish.
4. Have students discuss things (in small groups or as a class) that they noticed about the videos and what challenges they think the designers had to overcome to get everything to work properly. Notice that in many examples, items/moving parts move just enough to set off the next step and think about how they may have accomplished that. For example, how did they figure out exactly how much force they needed to make a tire roll just far enough to lightly bump the next part of the machine?
5. Introduce the challenge. If you're using the light/buzzer kits, explain how students need to touch the two foil pads together to make the buzzer. Demonstrate this in the front of the class. If not using the kits, then explain the challenge you've created for them to solve. If you've created your own Rube Goldberg Machine, demonstrate it now.
6. Explain that students will be building their own Rube Goldberg Machine and that it must have no less than 3 steps, and no more than 5 steps.
7. Ideally, this where Session 1 will end. Have students think about how they are going to complete their task before the next session. Instruct them that if they wish to use materials other than what is available in the boxes, they will need to bring them from home. BE SURE TO TELL THEM THAT NOTHING DANGEROUS WILL BE ALLOWED, I.E. FIREWORKS, ANYTHING FLAMMABLE, SHARP OBJECTS, ETC.

> You can also introduce the concept of efficiency and ask students if they think that Rube Goldberg machines are efficient ways to solve a problem. Brainstorm what efficiency means. Have students compare how little energy would be needed to simply flip a switch with your hand versus creating an elaborate machine to do the same thing.
>
> Formula:
>
> $$\text{Efficiency} = \frac{\text{Energy Out}}{\text{Energy In}} \times 100\%$$

Session 2:

8. Remind students that today they will be building their Rube Goldberg Machine. Explain to students that they must create their own machine by the end of the session and that they will need to demonstrate it to the rest of the students.
9. Read the instructions on the student handout out loud to student and make sure they understand them.
10. Before beginning, have students create a list of materials that they are going to use in their machine in their notebook. Also have them make a quick sketch of how they wish their machine to work and label it with the steps that their machine will perform.
11. Once students have finished writing/sketching, have them begin building their machines according to their specifications. Give them about 30 minutes to complete their task. Encourage creativity and novelty.
12. At the end of this time, have groups demonstrate their machine to the rest of the students. If students were unable to get theirs to work, have them explain how they were going to have it work.
13. Finally, have students reflect in their notebooks if their designs worked or not, challenges they had, and how they could improve the design if they had more time/materials, etc. Have them sign the page at the end of the activity. Explain how this process allows them to understand what they did, refer to it later, and how engineers and scientists keep logs for exactly the same reasons.
14. Have students share some of the challenges and frustrations they faced while putting together their machines. Ask them if they had to revise their designs based on what happened when they tried to put it together. Brainstorm some of the reasons that things didn't go quite as planned. Tie this in to how engineers and scientists must go through several iterations of a problem/experiment before things work or are able to be answered. Specifically relate the steps they did to the Engineering Design Process handout they pasted into their notebook.

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Web Resources
Videos:
Honda Rube Goldberg Video
http://youtube.com/watch?v=6bk0Hw8-Xno
http://teachertube.com/viewVideo.php?video_id=15955&title=Honda_Commerical_with_Rube_Goldberg

"Mythbusters" Rube Goldberg Machine
http://youtube.com/watch?v=lCYg_gz4fDo
http://dsc.discovery.com/videos/mythbusters-merry-blastmus.html

Muffin Making Rube Goldberg
http://dsc.discovery.com/videos/time-warp-frankenmuffin.html

Star Wars Rube Goldberg Video
http://youtube.com/watch?v=rspYOxcnaTk

Dog-food dispenser Rube Goldberg Video
http://youtube.com/watch?v=7tTNOX8jfno

Middle School Rube Goldberg Example
http://teachertube.com/viewVideo.php?video_id=101924&title=Middle_School_Rube_Goldberg_Project_at_Briese_s

If you do a search on YouTube or Teacher Tube for Rube Goldberg, you will find these and other videos to share with your students.

Websites/Online Games:
Rube Goldberg Official Site
http://www.rubegoldberg.com/

Goldburger to Go! A Zoom! PBS Game that lets kids fix the parts of a Rube Goldberg machine that makes and delivers a hamburger
http://pbskids.org/zoom/games/goldburgertogo/game.html

Armadillo Run – A game that uses physics principles and is loosely based on a Rube Goldberg style of accomplishing a task – in this case getting an armadillo safely to another location
http://www.armadillorun.com/

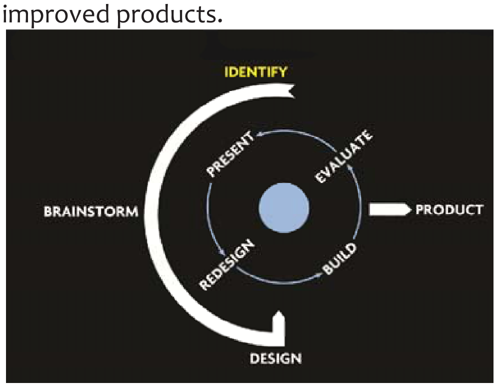
Other Games:
There are numerous computer games out there that mimic Rube Goldberg machines for students who may be interested. Some are older games, but can still be purchased on Ebay or other online stores. One such game is "The Incredible Machine."

Engineering Design Process – Student Handout

Your Engineering Design Notebook is a place to record ideas, inspirations, discoveries, sketches, and notes. You will begin using your Engineering Design Notebook in this first activity to record your thoughts and ideas. Some general guidelines include:

- Leave a few pages blank at the beginning to create a table of contents.
- Date and sign each page.
- Number each page.
- <u>Never</u> remove pages.
- DO NOT ERASE ANYTHING! ~~Cross things out, once, like this~~ so you can still read what you wrote (remember, the process you go through from "think" to "thing" is as important as final or "correct" answer).

The **Engineering Design Process (EDP)** is a series of steps that allows people to develop new and improved products.



Identify a Challenge – Find a problem that needs to be fixed. Be sure to think about constraints and limitations.

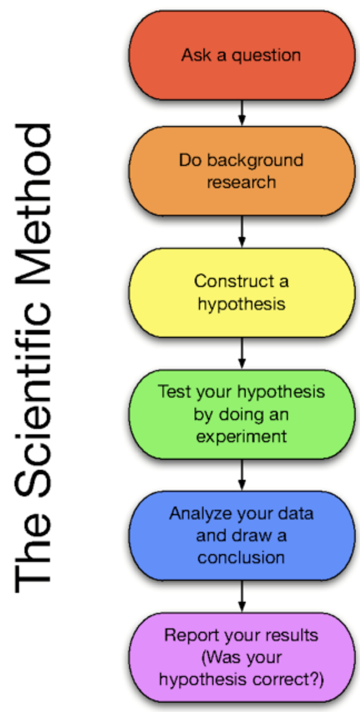
Brainstorm Ideas – Brainstorm ideas with the goal of figuring out several solutions for the problem. The proposed solutions could be sketched, drawn, and/or written.

Design and Develop – Create a final sketch of the best design solution. Then, materials needed to construct the new product are identified and the new product is built.

Test, Evaluate, Redesign – In this step, designers test the new product to see if it works as it was intended and if people would actually use it.

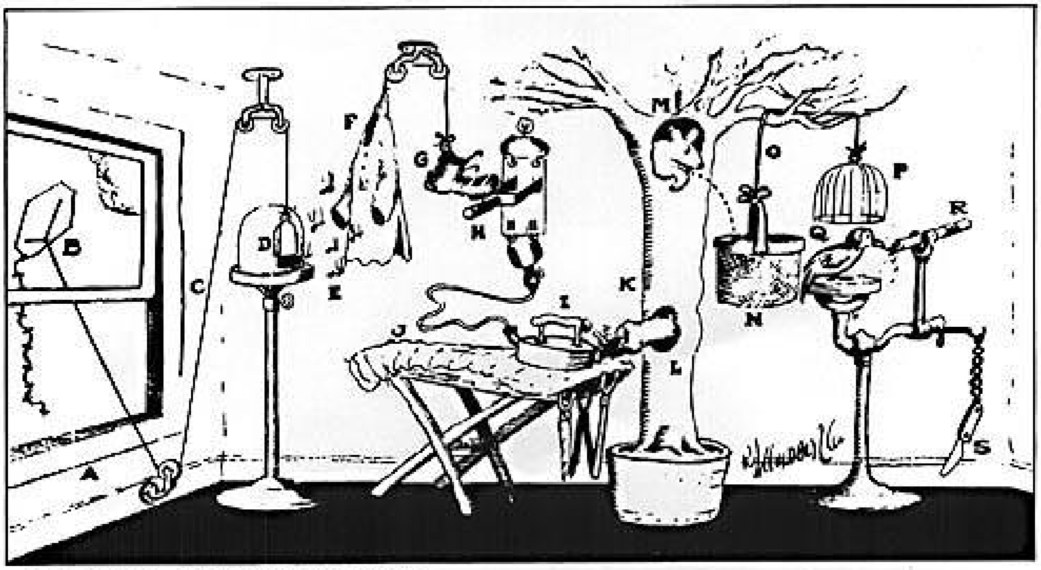
Present the Solution – Designers give a presentation and/or demonstration of the product to clients or managers to get additional feedback on their design. Sometimes feedback leads them back to the first step or may require a redesign or new test.

The **Scientific Method** is a series of steps that allows people to develop and test a question.



Cut out the box above and paste it into the front cover of your notebook. It will be your guide throughout the next several sessions.

Rube Goldberg Machines – Student Handout



Pencil Sharpener RUBE GOLDBERG (tm) RGI 038

Rube Goldberg gets his think-tank working and evolves the simplified pencil-sharpener: Open window (A) and fly kite (B). String (C) lifts small door (D) allowing moths (E) to escape and eat red flannel shirt (F). As weight of shirt becomes less, shoe (G) steps on switch (H) which heats electric iron (I) and burns hole in pants (J). Smoke (K) enters hole in tree (L), smoking out opossum (M) which jumps into basket (N), pulling rope (O) and lifting cage (P), allowing woodpecker (Q) to chew wood from pencil (R), exposing lead. Emergency knife (S) is always handy in case opossum or the woodpecker gets sick and can't work.

Background: Rube Goldberg was a cartoonist (and engineer) who is famous for his kooky drawings of elaborate machines which performed simple tasks. His work was so famous that his name became an adjective describing a complicated way to do something. Merriam-Webster's Dictionary defines "Rube Goldberg" as an adjective meaning: "accomplishing by complex means what seemingly could be done simply."

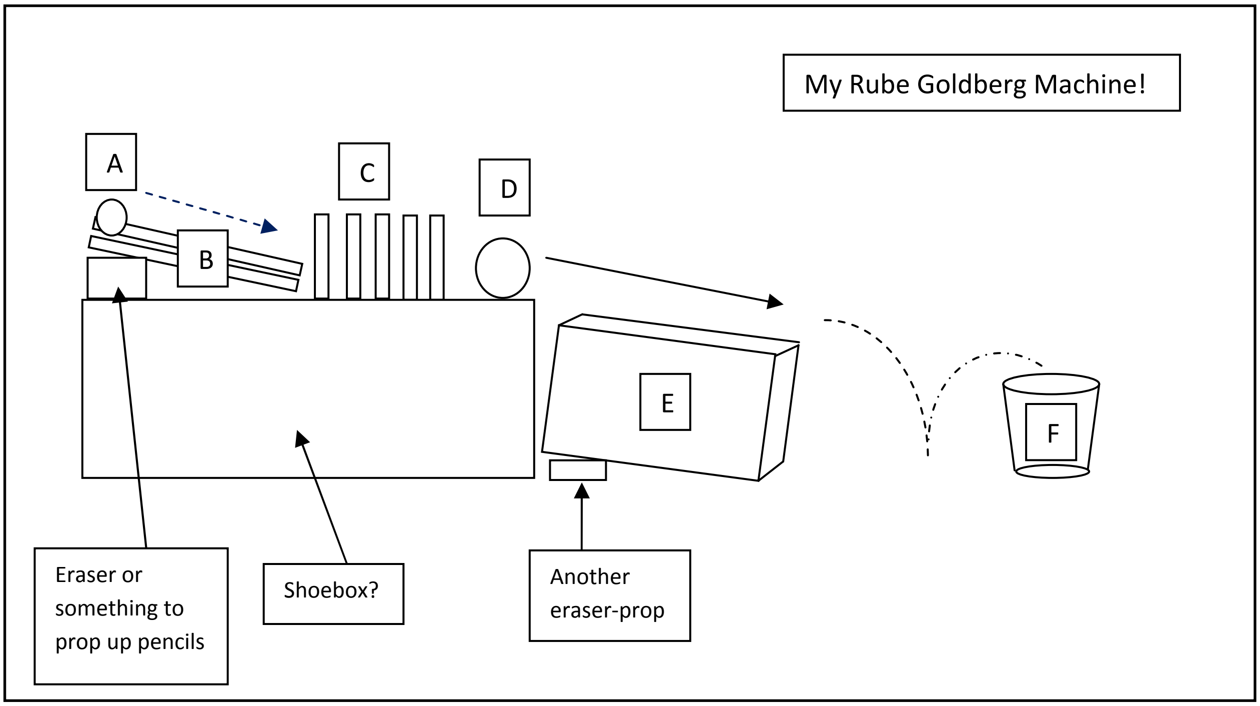
The Problem: Your job during this activity is to make a "machine" that will perform a task. Your machine should have between 3 – 5 steps. Your MESA Adviser will explain what task your machine is to perform.

Propose a Solution: Look around the classroom and through the materials your adviser provides. Find some items you'd like to use in your machine. Make a list in your design notebook called "materials" of the items you'd like to use.

Draw a Quick Sketch of Your Ideas: Before you start putting things together, make a list of the steps you'd like to have in your "machine," and draw a diagram (with the steps labeled A, B, C or 1, 2, 3) in your design notebook.

For example, if you were making a machine to get a rubber ball into a cup you might make the following list of steps and diagram:

1. Push marble (A)
2. Marble rolls down ramp made from two pencils (B) hits dominoes (C)
3. Dominoes fall down and then hit Rubber Ball (D), knocking it off the shoebox and onto book (E)
4. Rubber Ball (D) rolls down tilted hardcover book spine (E), bounces once on table and then into the cup (F)



Build Your Machine
After you've made your diagram, start building! Keep in mind that you may need to change your design slightly once you start experimenting with how things work together. Keep track of any changes in your notebook.

Reflect on the Process
When you're finished and your machine works, if you changed anything about your original design, draw a revised diagram of how your final machine worked and a revised list of steps. REMEMBER: DO NOT ERASE YOUR ORIGINAL DRAWINGS/MATERIALS LIST! They are important to see how things changed from what you first thought to what you ended up with.

Look at the handout that describes the Engineering Design Process (EDP) (you should have it pasted into your notebook). Answer the following question in your notebook: How does this process match up with how you planned, built, and tested your machine? Share some of your findings with other students.

Straw Tower Activity

Goal
Design and build a free standing straw tower. Students compete with one another to determine who can build the highest free standing tower with the same amount of building materials.

Description
Using scientific principles and their creative ability, students build a free standing paper tower using only straws, official paper and tape.

Supplies
For each group of 2-3 students:

- 50 straws
- 1 meter of masking tape

Rules

- The official time of the contest will be 45 minutes exactly.
- No other materials are to be used except those provided by the teacher.

Procedures

1. Explain the purpose of the activity to the students and then distribute the materials. Inform them that the free standing straw tower that is the tallest is the winner.
2. After 45 minutes, announce that time is up. Measure the height of each of the towers and determine the winner.

Heat Shield Design Activity

For details and materials about this activity, please visit our website.
http://oregonmesa.org/advisors/?attachment_id=166

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Build a Better Paperclip Activity

Goal
The purpose of this unit is to experience the **Engineering Design Process (EDP)** by redesigning a simple, everyday object.

Outcome
The students will use the EDP to design a paperclip and will be able to point out the steps of the EDP that they used.

Description
Given a set of wires and tools, students are challenged to design a new paper clip that meets predetermined requirements. This design challenge provides a firsthand connection with the 5-step **EDP** that was introduced in the Rube Goldberg activity. The **EDP** forms the foundation for work on students' own projects

Time
This unit should take approximately 60 minutes.

Materials (for 25 students):
- 10 pairs of needle-nose pliers
- 5 pairs of wire cutters
- 5 pairs of goggles or safety glasses
- Various types of paper clips (a variety of sizes, shapes and materials etc)
- 30 pieces of 14 gauge wire cut into 1 ft lengths
- 30 pieces of 18 gauge wire cut into 1 ft lengths
- Scratch paper – at least 2 pieces for each student plus several stacks of 10 pieces for testing paper clips.

Safety considerations: Students should wear safety glasses or goggles when cutting wire.

Preparation
Before Meeting:
- Make 1 double sided copy of the BABPC handout for each student
- Make sure you have enough supplies

Meeting Day:
If possible/applicable move desks so that tools can be shared in a groups of 3-4 and set out materials.
<u>Each</u> student gets:
- one 14 gauge piece of wire
- one 18 gauge piece of wire
- 2 pieces of scrap paper
- 1 straight pin (you may want to attach it to their handout)
- 1 handout

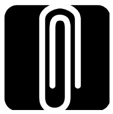
<u>Additionally:</u>
- Be sure that each group of 4 students has one pair of needle nose pliers and several examples of paper clips
- Set up wire cutting station - put goggles and wire cutters in the same place.

Procedures:

1. Review the **Design Notebook**. Remind students that the notebook is a place to record ideas, inspirations, discoveries, sketches, and notes. They will be using the **Design Notebook** in this activity to record their thoughts and ideas. Remind them that they should: date and sign each page, number each page, never remove pages, and do not erase (~~strike through instead~~).
2. At the start of this activity, identify the problem by introducing students to the Design Challenge: The owners of P&C Office Supplies are seeking new designs for paper clips. The company has come across hard times and believes a new paper clip design could revive its once-thriving business. It is up to you to save their company. Use your imagination and creativity to invent a new paper clip design. After researching their paper clip sales pattern, the owners have come up with requirements for the design. Please refer to them before you begin. (Refer to the handout with the design requirements, and allow time for students to read it thoroughly or have students read it out loud).
3. Describe the materials and tools for the design challenge. Discuss the different types of wire the students will be using and what is meant by wire gauge—the size of the wire's diameter. The higher the gauge number, the smaller the diameter and the thinner the wire. Pay special attention to the needle-nose pliers and wire cutters. Some students may not have experience with these tools. Take time to show students the correct way to hold and use the tools. Review the requirements with students before they begin brainstorming solutions to the design challenge.
4. Students should explore the examples/designs provided in the kit and make observations in their **Design Notebooks**. Remind them that all these fasteners represent different solutions to the same problem— holding papers together.

Build A Better Paper Clip is adapted from the Intel® Design and Discovery curriculum

Build a Better Paper Clip – Student Handout



We take paper clips for granted—it seems as if they've always been around. In fact, they've only been in use since the time of the Industrial Revolution. Before that, paper was held together with straight pins. However, the straight pin was difficult to thread through more than a few sheets of paper because it left holes in the paper, and it bulked up piles of paper.

The paper clip had a clear advantage over the straight pin in holding together a group of papers, and eliminated pricked fingers! Early versions of the paper clip had problems that later versions tried to fix. The paper clip we know and love today, with its (almost) perfect design, did not start out that way. Earlier models got tangled together, slipped off too easily, had too much or not enough "springiness".

http://www.designboom.com/weblog/cat/8/view/972/history-of-the-paper-clip.html

The Philadelphia was the first patented paperclip (in 1867 by Samuel B. Fayelt) it was actually invented to hold tags onto fine fabrics without damaging the fabric, but the patent acknowledges that it can be used to hold sheets of paper, too.

The most successful paper clip design so far is the Gem clip. The shape of the Gem clip was introduced in England in the late 19th century by a company known as Gem, Limited. The classic Gem paper clip has certain proportions that seem to be "just right." Interestingly, this paper clip, designed by William Middlebrook, was never patented, but the machine to make it was!

http://www.officemuseum.com/paper_clips.htm

Explore Existing Paper clips

In front of you there should be a straight pin and a paper clip. Use a straight pen to join two sheets of paper together. Try out some of the different paper clips.

Write your observations about the pin and the paper clips in your journal. What do you notice about how your hands and fingers have to move to use each one? You might notice how you separate the paper clip loops so it slips onto the papers, or the way your fingers have to move. Do you have to think about how it works? What is common about the way each works? What do you like and dislike about each?

Investigation of Materials and Tools

Investigate the materials and tools provided to you. Notice the different types of wire. The wire's diameter is measured in order to determine its gauge. The higher the gauge number, the smaller the diameter and the thinner the wire. The needle-nose pliers may be used to bend the wire into specific shapes.

The Challenge Background

The owners of P&C Office Supplies are seeking new designs for paper clips. The company has come across hard times and believes a new paper clip design could revive its once thriving business. It is up to you to save their company. Use your imagination and creativity to invent a new paper clip design. After researching their paper clip sales pattern, the owners have issued a design brief/problem. Please refer to it before designing your new paper clip.

Design Problem/Brief

- Your paper clip must be unique. It cannot look like any paper clip you have ever seen before, but it may have features of other clips.
- It can be no bigger than 2 inches by 2 inches (5 cm x 5 cm).
- It must hold 10 pieces of paper together.
- You may use other materials to enhance your design, but your main material must be wire.
- It must not have sharp ends.
- It should be useable by a variety of different people.

Explore Ideas

Make drawings of your ideas in your journal. What shape will you use? Where did you get your inspiration for it?

Plan and Develop

Select one idea to try. Engineer and test it. You may discover that you need to redesign your paper clip as you learn how to manipulate the wire. Redesign and build a second paper clip. Be prepared to present your final model.

You may use this square to test for the paper clip size requirement.

Reflect on the Process

Draw your final design in your notebook and write down how it works and what makes it a better paper clip.

Build A Better Paper Clip is adapted from the Intel® Design and Discovery curriculum

If the World Were a Classroom . . .

Goal
Students will "take on" the identity of a person very different from themselves.

Outcome
Students will develop empathy for the situations of people in other parts of the world.

Description
This exercise helps groups understand some of the factors that make up the REAL. LIFE. situations their peers in other parts of the world face every day.

This exercise is based on the book *If the World Were a Village*, by David Smith, who based his statistics on "State of the Village Report" by Donella Meadows, first published in 1990. An electronic adaptation of the book, Miniature Earth, can also be useful. Some of the statistics vary from Smith's book.

The premise in the book and Web site is that if we reduced the world's population to 100 people—the size of a small village—we can understand in a microcosm who the world's people are. We would feel closer to them because they are part of our village.

The premise of this exercise is to reduce the statistics to **your classroom or group**: If the world were your classroom or group....

Procedure

1. Examine the statistics listed below, selected from the If the World Were a Village (2002). ***REAL. LIFE. for people in our world***
    A. Access to food
        26 people are severely undernourished.
        34 people are always hungry.
        16 other people often go to bed hungry.
        24 people always have enough to eat.
    B. Access to safe water
        40 have no clean, safe water to drink.
        60 have access to safe water.
    C. Access to sanitation
        40 have no access to sanitation.
        60 have access to sanitation.
    D. Access to money
        20 people have more than $9000/year.
        30 people have more than $750/year but less than $9000.
        50 live on less than $2/day; of those, 20 have less than $1/day.
2. Based on the number of people in your classroom or group, **calculate the statistics**. (You can do the math yourself, or have the calculations be part of the assignment.)
3. For each item, create slips of paper with the "identities" on them. For example, if you have 30 people, the "Food access identity" statistics would be this:

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- 8 people are severely undernourished.
- 10 people are always hungry.
- 5 people often go to bed hungry.
- 7 people always have enough to eat.

4. Pass out eight slips of paper that say “Access to food: I am severely undernourished”; 10 that say, “Access to food: I am always hungry”; five that say, “Access to food: I often go to bed hungry”; and seven that say, “Access to food: I always have enough to eat.”
5. Repeat the exercise for the other access statistics. In the end, each person will have four slips of paper, each with an access statistic that forms his or her “identity” in each area. (Note that because the slips are handed out at random, people may end up with statements that contradict each other. For example, one person might have a food access identity that says, “I am severely undernourished” and a money-access identity that says, “ I have more than $9000 a year.”)
6. **Remind your group that:**
   - If they have food in their refrigerators, clothes on their backs, a roof over their heads, and a place to sleep, they are richer than 75% of the people in our world.
   - If they have money in the bank, money in their purse or wallet, spare change somewhere around their house, then they are among the richest 8% of the world’s population.
   - If they can speak and act according to their faith and their conscience without harassment, imprisonment, torture or death, then they have more freedom than nearly half of the world.

Related journal-writing questions

1. What were your identities?
2. How did they make you feel?
3. What would it be like if any of these identities were REAL. LIFE. for you?
4. What can you do on behalf of people for whom these identities are REAL. LIFE.

The Incredible, Edible Aquifer

Adapted from Idaho DEQ

Objective
To illustrate the geologic formation of an aquifer, how pollution can get into groundwater, and how this pollution can end up in drinking water wells. Students will come to understand how our actions can affect ground water and drinking water.

Time
30 minutes (can be longer or shorter depending on discussion)

Description
Students will build their own edible aquifers and learn about different geologic layers, different types of aquifers, how aquifers become contaminated, and the need to protect and conserve ground water resources.

Supplies (for a class of 25)
- Chocolate chips (4, 12 oz bags)
- Chocolate sprinkles (2, 3 oz containers)
- Clear plastic cups (12 or 16 oz) (25 - 30)
- Clear soda (e.g., lemon-lime) (4 liters)
- Crushed ice (the smaller the better)
- Gummy bears or worms (small) (2 lbs)
- Red Kool-Aid® (dry) (4 small packages)
- Spoons (25 - 30)
- Straws (clear work best) (25 - 30)
- Vanilla ice cream (½ gallon or 25 - 30 single serving cups)

Background
Ground water supplies 95% of the drinking water in Idaho. Wells are drilled through soil and rock into ground water aquifers to supply drinking water. Unfortunately, ground water can become contaminated by improper use or disposal of chemicals such as fertilizers and household cleaners. These chemicals can percolate down through the soil and rock into an aquifer, and eventually into drinking water wells. This contamination can pose a significant threat to human health.

Procedure
1. Fill a clear plastic cup 1/3 full (total) with a combination of gummy bears, chocolate chips, and/or crushed ice.
   These represent gravels and soils that make up the aquifer.
2. Add enough soda to just cover the candy/ice.
   The soda represents ground water. Notice that the soda fills all of the spaces among the gummy bears, chocolate chips, and ice. The aquifer is now saturated with soda; it is a "saturated zone." In an unconfined aquifer (see Step 3), the top of the saturated zone is called the "water table."
3. Add a layer of ice cream. (Optional)
   This layer, called a "confining layer" or an "aquitard," is impermeable or significantly less permeable than the aquifer below it (it is difficult for water to soak through). It helps protect the

aquifer from contamination and is usually made of rock and/or clay. An aquifer under a confining layer is called a "confined aquifer." An aquifer without a confining layer is called an "unconfined aquifer." Some aquifers, such as the Spokane Valley-Rathdrum Prairie Aquifer in north Idaho, do not have a confining layer. If your local aquifer does not (or even if it does), consider omitting the ice cream or having half the class use ice cream and half not to compare the results.

4. Add crushed ice on top of the confining layer/water table.
   This represents the unsaturated zone, the area where air fills most of the pores (spaces) in the soil and rock.
5. Scatter chocolate sprinkles over the top.
   The sprinkles represent the soil, which is very porous.

The aquifer is now complete. Your aquifers will probably be messy. That's OK! Real aquifers aren't neatly layered either.

6. Sprinkle Kool-Aid® over the top.
   The Kool-Aid® represents contaminants on the ground (e.g., fertilizer). Does anything happen to the Kool- Aid® right away? (Usually nothing will happen.)
7. Using a drinking straw, "drill" a "well" into the center of the aquifer.
   Observe the aquifer and Kool-Aid®. What, if anything, happens when the well is drilled?
8. Begin to "pump" the well by slowly sucking on the straw.
   Watch the decline in the level of the soda and observe what happens to the contaminants. Do contaminants (Kool-Aid®) leak through the confining area (ice cream) and get sucked into the well? If so, do more contaminants get into wells in confined or unconfined aquifers? (If your class made both; see Step 3)
9. Pour a small amount of soda over the top.
   The soda represents precipitation. It recharges the aquifer (adds new water). Watch how the Kool-Aid® dissolves and moves into the aquifer. The same thing happens when contaminants are spilled on the ground. Do you think you could get the Kool-Aid® back out of the soda?

Review what you have learned and eat your aquifer! Use the questions on the next page to start the discussion

Assessment/Follow-Up

Before the Activity:

 Ask students to define "ground water" and "aquifer." Record their key words on a white board to compile relatively accurate definitions. Leave the definitions on the board.

After the Activity:

 Complete "Questions for Discussion," above.
 Refer back to the definitions students wrote before the activity. Ask if they would like to modify them.
 Have students to list as many potential ground water contaminants as they can.
 Include vocabulary in spelling lists.
 Test on definitions of vocabulary.
 Have students research ground water and aquifers in your area and compile an oral or written report.

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Vocabulary:

Aquifer A natural underground area where large quantities of ground water fill the spaces between rocks and sediment.

Aquitard An underground layer over an aquifer that is impermeable or significantly less permeable than the aquifer below it. It helps protect the aquifer from contamination and is usually made of rock and/or clay. Also called a “confining layer.”

Confined Aquifer An aquifer overlain by one or more layers of impermeable rock or soil (aquitard/confining layer) that restrict water to within the aquifer.

Confining Layer An underground layer over an aquifer that is impermeable or significantly less permeable than the aquifer below it. It helps protect the aquifer from contamination and is usually made of rock and/or clay. Also called an “aquitard.”

Conserving Water Not wasting water.

Porous Full of pores (small spaces). Water can easily pass through it.

Protecting Water Keeping water clean.

Saturated Zone An underground layer or area where water fills most of the pores (spaces) in the soil and rock.

Unconfined Aquifer An aquifer that is not overlain by a layer of impermeable rock or soil.

Unsaturated Zone An underground layer or area where air fills most of the pores (spaces) in the soil and rock.

Water Table The top of an unconfined aquifer.

Water: Source of Health, Source of Illness

Adapted from World Wise Schools Water in Africa Program
http://www.peacecorps.gov/wws/educators/enrichment/africa/lessons/MShealth01/index.html

Objectives

Students will

- Explore the connections between water and disease.
- Be able to describe the causes of, and prevention strategies for, a major waterborne illness.

Description

Although we need water to sustain life, it can also serve as a conduit of illness and even death. In this unit, students examine the connections between water and disease in four West African countries. Students will become familiar with general concepts related to waterborne illness by viewing photographs and reading vignettes collected from in-service Peace Corps Volunteers.

Time

1-2 sessions

Supplies (hyperlinks on website)

http://www.peacecorps.gov/wws/educators/enrichment/africa/lessons/MShealth01/index.html
World map
Map of Africa
The following images from the *Water in Africa* website:
Cameroon—CM0212, CM0224, CM0225, CM00230, CM0233, CM0235, CM0714
Togo—TG0117, TG0130, TG0115
Ghana—GH0304, GH0308, GH0622
Guinea—GN0105, GN0318
Health and Nutrition Retrieval Chart (PDF)
Health and Nutrition Vignettes for Ghana, Cameroon, and Guinea,
Waterborne Illness Research Chart (PDF)
Research materials (Internet or traditional)
Internet Research on Waterborne Illnesses (PDF)
Evaluation Rubric (PDF)

Procedure

1. Pose the essential question "How does water affect health?" Lead a discussion that brings out the connection between water and health and between water and disease. Ask students to make a list of ways in which water sustains life and then to list ways in which water can cause illness or death. Have students share their lists with a partner and then make a class list on the board.
2. Tell students that they will be learning about the experiences of Peace Corps Volunteers who are living in African countries that struggle to maintain an adequate supply of clean water. To become familiar with terms and concepts they will encounter while reading selections written by Volunteers, they will view photographs taken by Volunteers serving in Togo, Cameroon, Ghana, and Guinea. Show the locations of these countries on a world map or a map of Africa.
3. Show the following photographs and captions from the *Water in Africa* website: CM0212, CM0224, CM0225, CM0230, CM0233, CM0235, CM0714, TG1017, TG0130, TG0115, GH0304,

GH0308, GH0622, GN0105, GN0318. As you view the photographs, explain unfamiliar terms (e.g., borehole, forage, river blindness) and encourage students to think about how the photographs help to answer the essential question "How does water affect health?" Explain that they will be researching the causes of, and prevention strategies for, waterborne diseases.

4. Distribute copies of the Health and Nutrition Retrieval Chart (PDF) and divide students into four "expert groups." Each group will be reading vignettes on health and nutrition from Ghana, Cameroon, Guinea, or Togo. They will then work with others in their expert group to fill out the retrieval chart.
5. Once each group has completed its chart, put students into groups of four that include one student representing each of the expert groups. Tell students to take turns sharing the information they entered on their retrieval charts with the other members of the group until everyone has a complete chart. For example, student A talks about Togo while the others in the group take notes; student B then does the same thing for Cameroon, etc.
6. Instruct students to work in these groups to create a coordinated campaign to fight against one of the waterborne illnesses they have read about. They will need to do some additional research about the illness beyond what they have learned through the Peace Corps selections in order to plan an effective campaign. Pass out the Internet Research (PDF) sheet to students and let them visit the sites on it to begin to locate information about waterborne illnesses. They should use the waterborne Illness Research Chart (PDF) for help in organizing their research.
7. Toward the end of the period, ask students to stop and give you their attention while you describe the public-awareness campaign that will be their assessment project. Their campaign could include a public-service announcement for the radio, a skit to be performed in front of a village, and a series of posters, storyboards, or billboards. The campaigns will be presented to their classmates and could then be sent to an international organization that works to fight waterborne illness. In order to present their campaigns to both of these audiences, students will need to have scripts for their public-service announcements and skits. Visual aids that are too large to be sent in the mail should be photographed.
8. Show sample public-service announcements, skits, and visual aids to students. Discuss what made them interesting and educational.
9. Instruct students to continue with their research and begin their projects. Monitor the work on their health campaigns and act as a mentor, providing advice as they work in their groups.

Additional Resources on Waterborne Diseases

Water.org
http://water.org/learn-about-the-water-crisis/facts/

Safe Water is Essential
http://www.drinking-water.org/flash/splash.html

World Health Organization – Water, Sanitation, and Health
http://www.who.int/water_sanitation_health/en/

The Carter Center
http://www.cartercenter.org/health/index.html

About the Author

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Waterborne Illness Research Chart

Directions: Take a look at the information about health and sanitation that you have been assigned. Take notes on what you learn in the appropriate places on the chart below.

Country: ________________________

Name of Disease	What causes the disease?	What can be done to prevent or treat the disease?	Sources (where did you get the information?)

Adapted from: Water: Source of Health, Source of Illness, Peace Corps, www.peacecorps.gov/wws/water/africa/

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SCAMPER – Teacher Guide

Goal: Introduce and practice SCAMPER, a creative technique for improving existing designs. Students doing Water Transportation System Projects will redesign buckets for a particular client/situation. Students doing Water Filtration Projects will redesign a Brita Water Filter for a particular client/situation.

Outcome: Students will be able to use SCAMPER to evaluate and define solutions to a specific design problem.

Description: SCAMPER is an acronym for a useful list of words that can be used to help you think differently about a problem. The students will learn what scamper stands for and use it to look for ways of improving an everyday item of your choice. Then, students are asked to apply SCAMPER to their chosen problem as a part of the design process (finding a solution).

SCAMPER

Substitute What can you substitute? What can be used instead? Who else instead? What other ingredients? material? process? power? place? approach? sounds? forces? Instead of ___. I can ___

Combine What can you combine or bring together somehow? How about a blend, an alloy, an assortment, an ensemble? Combine units? purposes? appeals? ideas? I can bring together ____ and ___ to ___.

Adapt What can you adapt for use as a solution? What else is like this? What other idea does this suggest? Does past offer a parallel? What could I copy? Who could I emulate? I can adapt ___ in this way ___ to ___.

Modify Can you change the item in some way? Change meaning, color, motion, sound, smell, form, shape? Other changes? Also: *Magnify*: What can you add? More time? Greater frequency? Stronger? Higher? Longer? Thicker? Extra value? Plus ingredient? Duplicate? Multiply? Exaggerate? And: *'Minify'*: What can you remove? Smaller? Condensed? Mini? Lower? Shorter? Lighter? Omit? Streamline? Split up? Understate? I can change ___ in this way ... to ___

Put to other uses How can you put the thing to different or other uses? New ways to use as is? if it is modified? I can re-use ___ in this way __ by___.

Eliminate/Elaborate What can you eliminate? Remove something? Eliminate waste? Reduce time? Reduce effort? Cut costs? And *Elaborate* What can be expanded or developed more? I can eliminate/elaborate ___ by ___.

Rearrange/Reverse What can be rearranged in some way? Interchange components? Other pattern? Other layout? Other sequence? Transpose cause and effect? Change pace? Change schedule? I can rearrange ___ like this __ such that ___.

Time: This unit should take approximately 40 minutes.

Materials: (for 25 students):

- Examples of items that have been SCAMPERed such as can openers, water or pens.
- Copies of two-sided student handout

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For Water Transportation System Project

- A 5 gallon plastic bucket for each group
- Copies of the Water Transportation System Client Cards (so that each group gets a different client/situation)

For Water Filtration Project

- A sample Brita water filter for demonstration and one cheap plastic pitcher for each group to modify.
- Copies of the Water Filtration Client Cards (so that each group gets a different client/situation)

Safety considerations: None

Procedures:

1. Have students read SCAMPER handout as a group.
2. For Water Transportation System projects, demonstrate how a bucket can be used to transport water. Brainstorm with students about who, specifically, could easily use a bucket to move water. Would it work for everyone in every situation?
3. For Water Filtration projects, demonstrate how a Brita filter works. Brainstorm with students about who, specifically, would use a Brita filter. Would it work for everyone in every situation?
4. Provide each group with a bucket (for Transportation) or filtration container/plastic pitcher for Water Filtration) and a client/situation card.
5. Ask students to go through the different letters of SCAMPER redesign on the student handout based on their particular client.
   * For the water filter redesign, students should not worry about the actual filtering of water. They should be focused on redesigning the shape, size, and input/output regions of the container. They will focus on the specifics of filtration later. *
6. Students should draw a picture of their redesigned bucket/pitcher. If you have the time and resources, students can build models of what their modified design would look like.
7. If you have time, have student share their design and how it meets their specific client needs.

SCAMPER – Student Handout

SCAMPER is an acronym for a useful list of words that can be used to help you think differently about a problem.

Substitute one thing for another.
Combine with other materials, things, or functions.
Adapt: Can it be used for something else?
Minimize/magnify/modify: Make it larger or smaller.
Put to other uses: Can you put it to another use?
Eliminate/elaborate: Remove some part/material, make one part more detailed/refined.
Reverse/rearrange: Flip-flop some section of the item, move parts around.

Here are some improvements that can and have been made to water bottles. Can you think of any more improvements by using the SCAMPER technique?

SCAMPER	Questions to Ask	Water Bottle Improvement	Benefit
Substitute	What could be used instead? What kind of alternate material can I use?	Different bottle material	Plastic bottle is unbreakable, unlike glass
Combine	What could be added? How can I combine purposes?	Add straw into top	Straw allows access to bottom of water bottle without lifting and tilting bottle
Adapt	How can it be adjusted to fit another purpose? What else is like this?	Use squirt top for watering plants	Directed stream gets water to the plant roots
Magnify	What happens if I exaggerate a component? How can it be made larger or stronger?	Larger bottle	More water for better hydration
Minimize	How can it be made smaller or shorter?	Smaller bottom of bottle	Can store in car's cup holders easily
Put to other uses	Who else might be able to use it? What else can it be used for other than its original purpose?	Turn upside down	Hand washing station
Eliminate	What can be removed or taken away from it?	Eliminate the handle	More volume for water storage
Elaborate	What can be expanded or developed more?	Larger base Lower center of gravity	helps keep water bottle from tipping
Rearrange	Can I interchange any components? How can the layout or pattern be changed?	Move handle from side to top	Better ergonomics for hauling large amounts of water
Reverse	What can be turned around or placed in an opposite direction?	Water spout at bottom	Easier to dispense water into cups

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SCAMPER – Student Handout

Now try using SCAMPER yourself. Fill out the answers to the questions below using the item given to you by your advisor:

Substitute: Instead of ____________________ I can ______________________.

Combine: I can bring together ____________________ and _______________

to _____________________________.

Adapt: I can adapt _________________ in this way _______________________

to _____________________________.

Modify/Magnify/Minimize: I can change _______________________ in this way

_______________________ to ________________________________.

Put to other uses: I can re-use ________________________ in this way

_______________________ by ___________________________________.

Eliminate/Elaborate: I can eliminate/elaborate___________________________ By

____.

Rearrange/reverse: I can rearrange/reverse _________________ like this

_______________________ such that _________________________________.

In your design notebook, sketch some drawings of possible solutions for your client's needs.

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SCAMPER (Water Filtration) Client Cards

Give each student group one client card. They should SCAMPER (redesign) the Brita filter for the particular situation on their card.

* For the water filter redesign, students should not worry about the actual filtering of water. They should be focused on redesigning the shape, size, and input/output regions of the container. They will focus on the specifics of filtration later. *

Port-au-Prince, Haiti

An experienced aid worker, Brett is on Save the Children UK's Emergency Roster for water, sanitation and hygiene and was called to go out to Haiti within 48 hours of the earthquake, which devastated the island on January 12, 2010, claiming over 220,000 lives and leaving an estimated 1 million people homeless.

Hundreds of thousands of survivors are currently living in temporary camps in Port-au-Prince and the surrounding towns where there is a high risk of flooding, landslides and communicable diseases. With the imminent onset of the rainy season and the start of the hurricane season in June the dangers are all too real.

Redesign your filtration container so that it could be used in a temporary camp where hundreds of thousands of people are living. It will need to be large and stationary.

Mbale, Uganda

In the early 1990s, Mugwano's eyesight began to weaken, and his skin developed lumps and severely itchy rashes.The unbearable itching forced Mugwano to scratch his legs with rocks and coarse sticks, cutting them open and permanently disfiguring his skin. His symptoms became increasingly worse until he could no longer concentrate on his work. Neither he nor his family knew what was ailing him, but many in the village suggested that he was bewitched. Eventually people feared Mugwano, and he was abandoned by his three wives and exiled from Bunawazi.

"I hated myself. I knew I was going to die and be eaten by dogs since no one wanted to be near me," he remembered. Mugwano was suffering from river blindness (onchocerciasis). Spread by the bites of tiny black flies, parasitic worms enter the body, mature, and reproduce. The offspring, known as microfilariae, swarm under the skin and cause intense itching. If the microfilariae migrate to the eyes, vision can weaken and lead to blindness.

Redesign your filtration container so that it could be used by someone who has been blinded by River Blindness.

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East Province, Cameroon
by Karen McClish, Belita II

My drinking water is not "fresh." The children are constantly sick with different waterborne illnesses. Children often need to stay home from school because they are so sick. My neighbors know that they should boil their water to kill these critters and prevent their families from getting sick, but that takes time and energy (find the wood, start the fire, boil the water...). Not to mention that they would need to boil water for 10 to 15 people, the average family size here. So they don't do anything and they continue to get ill.

Redesign your filtration container so that it could be used by a family of 10-15 people. It needs to be stored inside or just outside their house.

Bogo, Extreme North Province, Cameroon
by Maryanne Pribila

Bogo is a large community and, as such, has a variety of water sources. During the rainy season, one side of the town turns into a lake. Herdsmen bring their cattle there to drink, and people bathe, wash their clothes, and drink from it. It is said to have a good taste, but I wouldn't want to try it myself.

During the rainy season, people may drink the rainwater they collect off their roofs. Although it may be clean, it can easily be contaminated by flies or by a dirty storage container. As a result, people in the village are often ill with chronic parasite problems and sometimes even more serious illnesses such as hepatitis and typhoid. A large problem is that they are unaware of how diseases are passed through water.

Redesign your filtration container so that it can be used to collect water from a roof. It would be stored just outside a house.

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Banko, Guinea
by Shad Engkilterra

The drinking water in Guinea is likely to be contaminated with any number of parasites—the most common among Peace Corps Volunteers are giardia and amoebas. I have had protozoa, and there have been cases of schistosomiasis. Conakry, the capital, has had two outbreaks of cholera in the last year.

These diseases are mostly gastrointestinal and can cause diarrhea. This is the leading cause of death among children in the region. Children often miss many days of school due to illness. Stagnant water is the breeding ground for mosquitoes, which transmit malaria, another killer of many people. The black biting flies that transmit onchocerosis—a leading cause of blindness—live around rivers.

Redesign your filtration container so that a small child could easily use it.

Timergarah, Pakistan
August 5, 2010

Lower Dir is an area of Pakistan severely hit by monsoons and floods. The local health clinic has already received an influx of patients from the area, including many who lost their homes.

People are worried that waterborne diseases such as diarrhea and cholera will spread among the displaced families and children. Increasing numbers of children are already reported to be suffering from skin diseases and eye infections.

"People are showing up at the clinic parched and hungry. They've walked through rain and mud with clothing caked to their bodies, carrying their children for hours. They're suffering from ailments such as diarrhea and acute respiratory infections, which can become life-threatening unless treated. The situation is desperate," said Dr. Sheraz Iqbal, a physician with World Vision in Pakistan.

Redesign your filtration container so that it could be used by someone who is walking long distances over varied terrains. It should be light, packable, and easy to use in lakes, streams, or puddles.

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Acids and Bases

Adapted from Discovery School

Objectives
- Use supporting evidence to predict if common household substances are acids or bases.
- Determine the pH of the substances.

Description
Students predict if common household products are acids or bases. Then they measure their pH using litmus paper and a pH meter, if available. If time permits, students may use phenolphthalein and note its color change in the presence of an acid and a base. Students will record their results and work in groups to draw conclusions.

Supplies
- paper and pencils
- litmus paper
- pH meter (if available)
- plastic cups (to hold the materials to be tested)
- distilled water
- lemon juice
- vinegar
- baking soda
- ammonia
- phenolphthalein (if available)

Preparation
Prior to the start of the class, decide how you would like to handle the distribution of the materials for the investigation. One student from each group can come up to a central area to collect the materials, or you can hand out the materials to each group.

Each group will need the following materials:
- 8 strips of litmus paper
- samples of these materials in a cup: distilled water, lemon juice, vinegar, baking soda, and ammonia
- pH meter (if available)

Procedures
1. Begin the lesson by asking students to write on scrap paper materials they can identify as an acid or a base. (If they cannot answer the question, tell them not to worry.)
2. Tell students that they are going to measure the pH of common household substances to determine if they are acids or bases. Explain that pH is measured on a scale of 0–14. Substances with a pH lower than 7 are acids; those with a pH higher than 7 are bases; and a substance with a pH of 7 is neutral. If students would like a little more background information before conducting the investigation, suggest that they watch the first three segments of the program "Elements of Chemistry: Acids and Bases." They can watch the final segment, "China: Surviving Vinegar," to gain an understanding of the important role that chemistry plays in everyday life.

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3. Divide students into groups of three. Make sure each group has the materials needed for the experiment and ask the students to predict whether they think these materials are acids or bases. Encourage students to write a reason for their predictions. Then have students put their predictions away until later in the lesson.
4. Give each group a few minutes to read the directions for the investigation, listed below.

Safety note: When working in the lab, always wear goggles, gloves, and an apron. Never touch, sniff, taste, or mix any materials that you are working with as part of a science experiment.
• Have the materials you need in front of you. Then place one end of a strip of litmus paper into each of the materials.
• Compare the color on the strip of litmus paper to the color scale provided by your teacher. Determine the pH of each material. Record the pH on a chart, indicating whether the material is an acid or a base.
• If a pH meter is available, measure the pH of each material with it. Record the pH obtained in this way next to the pH obtained by using litmus paper.

5. Remind students to record their observations as the investigation progresses. They may develop a chart similar to the one shown below.

Material	**pH Prediction (acid or base?)**	**pH Litmus Paper**	**pH pH meter**	**Observations**
distilled water				
lemon juice				
vinegar				
baking soda				
ammonia				

6. During the next class period, discuss the investigations and the outcomes. Ask volunteers to share their predictions with the class. Did any groups predict which substances were acids and which were bases? Were the students able to explain their reasons?
7. Continue to discuss the investigation. Ask students why litmus paper can determine the pH of a substance. If necessary, explain that some materials have the characteristic of changing color in the presence of an acid or a base. In general, litmus paper turns from blue to red in the presence of an acid and from red to blue in the presence of a base.
8. Work as a class to further explain the results of the investigation. Which of the substances tested were acids? (*vinegar and lemon juice)* Which were bases? *(baking soda and ammonia)* What was the pH of distilled water, and what does that reading mean? *(Distilled water has a pH of 7, so it is neutral.)*
9. If students also used a pH meter, ask them to compare the results they obtained with that device to their results with litmus paper. Were the results different? *(Students probably obtained more precise results with the pH meter, but the litmus paper is sensitive enough to indicate an acid or base.)*

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10. If time permits, give students the option of performing another experiment. Give each group a beaker containing about 100 ml of water; then hand out droppers. Have each group put about three drops of phenolphthalein, another pH indicator, into the water. Tell each group to record their observations. *(The water is now a colorless solution.)*
11. Next, have students add a few drops of ammonia. What happens to the water now? *(It becomes reddish purple.)* Ask students to explain what they think happened. If they are having trouble, have them refer to their experimental results with litmus paper for some clues. *(Ammonia is a base, so adding it to water causes the solution to become basic as well. Phenolphthalein has the property of turning reddish-purple if its pH exceeds 8.3.)* Then tell students that they will be adding a few drops of vinegar to the solution next. Ask them to predict what they think happens. (*The solution becomes colorless again.)* Ask students to explain why. *(The solution is becoming more acidic, causing it to lose its color.)*
12. Conclude the lesson by asking students to revisit their notes from the beginning of the lesson. Ask students to modify their list and add new materials based on what they have learned. Suggest that they write a short paragraph summarizing what they learned as a result of completing these investigations.

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Turbidity Lesson

Adapted from the EPA's Water Sourcebook

Objectives

The student will do the following:

- Define turbidity.
- Describe the effects of turbidity on aquatic ecosystems.
- Measure turbidity levels.
- Compute average turbidity.

Supplies

- white gallon milk containers (1 per group of 2-3)
- black markers
- rulers
- scissors
- large petri dishes
- Secchi disc
- meter sticks
- stapler
- ball of string marked in 1cm units
- 4-5 light-colored small buckets
- dirt
- water
- 100 mL beakers
- Turbidity meter or cylinder, if available

Background Information

Turbidity is defined by the American Public Health Association as the "optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample." In other words, "How cloudy is the water?" The amount of suspended material present determines the ability of light to pass through water. Turbidity may be caused by large amounts of silt, microorganisms, plant fibers, sawdust, wood ashes, chemicals, coal dust, and plankton. Soil erosion from agriculture, mining, logging, dirt roads, construction, and dredging operations contribute to the silt problem.

The most accurate way to determine water's turbidity is with an electronic turbidimeter. The turbidimeter is a photoelectric cell that accurately measures the light scattered by suspended particles in a water sample. The results are reported in units called Nephelometric Turbidity Units or NTUs. Turbidity can also be measured by filtering a water sample and comparing the filter's color to a standard turbidity color chart or by a device called a Secchi disc that determines turbidity from a sample's clarity.

Turbidity affects fish and aquatic life by:

- Interfering with sunlight penetration that, in turn, results in lower oxygen concentration and large carbon dioxide concentrations.
- Clogging the gills of fish and shellfish and killing them directly.
- Providing a place for harmful microorganisms to grow.

- Reducing the visibility for certain fish to find food but, on the other hand, helping protect from predators.

The table below shows the amount of fish and plankton per acre that may be expected in ponds of different turbidities.

FACTOR MEASURED	CLEAR PONDS	INTERMEDIATE PONDS	MUDDY PONDS
Average turbidity units	Less than 25	25-100	over 100
Amount of fish in ponds per acre	162	94	29
Comparative amount of plankton	12.8	1.6	1

Preparation

1. Discuss the use of Secchi disc with students. These discs are lowered into a pond or lake with rope that has measurement markings on it. The disc is lowered to a point where it is no longer visible and then raised up through the water until it becomes visible. The depth of visibility is measured and compared to a chart. The depth of visibility is determined by the degree of turbidity in the body of water.
2. Prepare 4-5 buckets of turbid water using tap water and local soil in various ratios. Mark the ratios on the buckets. Try the Secchi disc experiment on each bucket to make sure that some have no visibility.
3. Prepare a chart on the board for data from each group.

Procedure

1. Discuss Background Information with students and review vocabulary.
2. Have the students work in groups of 2-3. Number the groups for chalkboard recording purposes.
3. Each group needs 1 white gallon milk container, black permanent marker, ruler, large petri dish, scissors.
4. Cut out one complete side of the milk jug and place it under the lid of the petri dish a nd draw a circle. Cut it out. Use the ruler to divide and mark the circle in quarters. Color 2 opposite quarters black. This will resemble a small Secchi disc that is used to measure the clarity of water. Attach a string ½ meter in length to the middle of the disc with a stapler and mark the string every centimeter.
5. Have students stir each turbidity bucket and then immediately lower the Secchi disc into the bucket.
6. The disc should be lowered until it is no longer visible.
7. Have one student record the distance from disc to water surface using the meter stick or by the centimeter marks on the string. Record data on Data Sheet.
8. Each group should repeat steps for each bucket and record data on Data Sheets and on the board.
9. Obtain measurements from the other groups that were recorded on the board and calculate an average for each sample. Record the values on the Data Sheet. The smaller the measurement, the greater the turbidity.
10. If a turbidity meter is available, use it to measure turbidity of each sample. Have students compare their secci disc turbidity with that derived from the turbidity meter.
11. Have students compare the turbidity of a local river or stream during fair weather conditions and immediately after a storm. Ask how could one help prevent increase of turbidity resulting from farming or logging.

Follow-up
Have students bring in various water samples and align them by a visual observation in order of turbidity. Place each on the sheet of white paper and label the source of each. Discuss what caused turbidity in each sample by discussing the factors surrounding the body of water from which it was taken.

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Meet the Client

Goal

- Students will learn about the specific user they will be designing an invention for.
- Student groups will begin brainstorming ideas to solve their client/user's problem.

Outcome

Students will understand their client's problem and groups will narrow down solutions to 2-3 good designs.

Description

In this activity, students will listen to their client describe their problem and design challenge (through video footage). Using this information, students will work in small groups to begin to brainstorm solutions to their client's problem.

Time

This activity is expected to take about 1 hour.

Materials

- MESA student notebooks
- Copies of Student Handout (1 per group)
- Video: "Clean Water for Haiti" http://www.youtube.com/watch?v=LPAWuws7qMM (5:38 sec)

Preparation

Before meeting:

- Be sure to find the appropriate video on MESA Adviser website
- Read over student handout
- Copy handout – 1 for each student
- Have notebooks ready

Procedure

1. Introduce lesson and tell students that they will learn about a specific problem related to water, and begin to brainstorm potential solutions. Explain that students are going to be inventing a product that will solve either the problem of water transportation or water filtration. For the purposes of this project, the client is probably a whole group of people who are lacking easy access to clean water.
2. Split students into groups of 2-4. During the video, have each group fill out the Meet the Client Student Handout. Ask them to fill in the section labeled "What is the problem?" first. Ensure that all students understand what the problem is before they move on!
3. After the video, groups can begin to brainstorm solutions to the problem by filling in the boxes on the Student Handout.
4. By the end of the session, student groups should have 2-3 possible solutions to their client's problem. They can use the next MESA session to make some decisions!

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Meet the Client – Student Worksheet

With your group, fill in the boxes based on what your client says in the video.

Client Name (s): ____________________________________

Client's country/town______________________________

What is the problem?
What is your client's design challenge?

What does the **function** need to be?
What does the solution need to do?

What are the **constraints**?
Are there restrictions on space, money, materials, etc?

Who are the **users**?

What **solutions** already exist?
Brainstorm, look in catalogues, Internet search

Why won't they work in this situation?

What are their needs?

Now flip this onto the back, and brainstorm some possible solutions to the problem!

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Writing a Design Brief

Outcome
Students will write a Design Brief describing their chosen problem and solution.

Description
In the proceeding sessions, students have written bits and pieces about their design in their Design Notebook. In this session, it is all brought together into a Design Brief.

Time
This lesson should take only part of a MESA session. It may take students a couple of weeks to fill in all the pieces of their design brief.

Materials
Student Design Notebooks

Preparation
- Copy enough of the design brief for each group to have one (be sure to copy the design brief for YOUR project, either Water Transportation or Water Filtration)

Procedure
1. Explain that the specific challenges and requirements for their invention are outlined in the design brief.
2. Go over the design brief as a class. If you'd like, you can show students the sample design brief (Bass Space). We have already filled out the boxes for Design Challenge and Product Requirements. MAKE SURE STUDENTS UNDERSTAND THE PROBLEM (design challenge and product requirements) THEY ARE TASKED WITH!
3. Have groups fill out the User Profile and Background Information based on their Meet the Client Worksheet.
4. Groups should brainstorm solutions to the problem over the next week or two. They may need Internet access and time to look at possible materials to help them choose a solution. Once they have selected a solution and it is approved by you, they can describe it in the Proposed Solution and Sketch sections of the Design Brief.
5. Save completed Design Briefs in a safe place! The information can be used as students build their inventions (as a reminder of the problem and requirements). It will also be used to facilitate creation of poster boards!

What Does a Design Brief have in it?
These are the parts that must be in your design brief:
1. **A description of the design challenge.** A problem statement that focuses on what's wrong.
2. **A description of how the current product (if any) is used.** A context for the problem and explanation of any related solutions that resemble or relate to the challenge but have failed to address the problem.
3. **A description of a typical user (user profile).** This addresses who uses the product and how their needs are or are not met. How will they benefit from a different product.
4. **A proposed solution.** A description of how your solution will work, and how it solves the problem. Explain the features.
5. **A quick sketch of your ideas.** This is a rough sketch and can include drawings of different angles .

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6. **A description of the basic requirements that will best suit the proposed product.** For example, this describes the quality (for example: flexible or sturdy), and the type of materials (for example: metal or plastic.

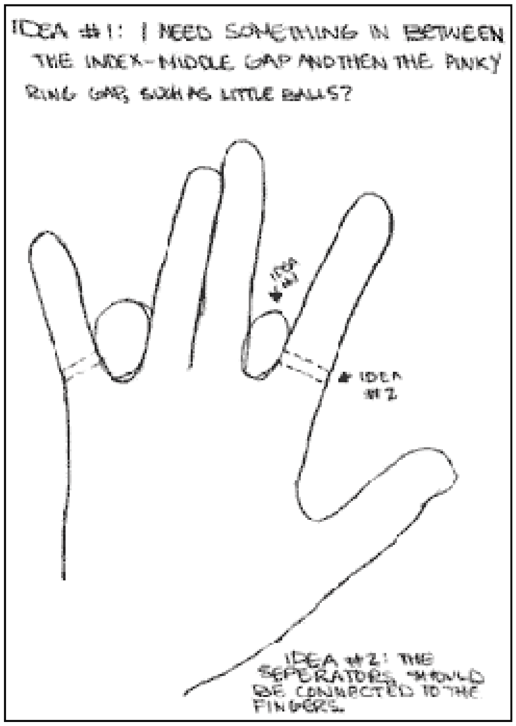
<u>**Example design brief: Bass Space** (patent pending).</u>

The Design Challenge

When people start playing the string bass, most beginners cannot hold their hand correctly, preventing them from being able to play properly. As a string bass player, I have had personal experience with this and have seen other beginner string bass players also struggle with this.

Background Information

Currently, there is not a product for this. Sometimes, a string bass teacher may tell her students to tape their fingers together.



User Profile *A typical user is a beginning string bass player who struggles holding their hand correctly.*

Solution

I'm not sure what type of material I would use, but the Bass Space would allow the player to keep her two middle fingers together and separate from her pointer finger and pinky. It would be adjustable in size depending on the size of the person's hands.

Product requirements

The material needs to be stiff yet flexible to allow hand movement, it cannot break easily, it has to be adjustable for different size hands, will need to slide on and off easily, must be low on the fingers to allow the fingers to bend, must be cost efficient, must hold hand correctly, and it must be comfortable.

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Design Brief – Water Filtration

The Design Challenge

The problem is that many people in the world do not have access to clean, drinkable water. One place that has a lot of water filtration problems right now is Haiti.

Our challenge is to design a product that could be used in Haiti to filter the impurities out of dirty water. Our product needs to improve the turbidity of dirty water, so that it is closer to the cleanliness of drinking water.

Write a brief description of the problem or challenge you are working on.

Product Sketch

Sketch your product.

Solution

Describe your solution to the problem. Describe how the solution works.

Background Information

Are there any products similar to yours? How does your product improve them?

User Profile

Who will use this product?

Product Requirements

Our device must cost less than $20 to build. It also needs to be made mostly of materials that can be easily found in Haiti (mostly scrap materials – wood, metal, cheap plastic, sand, gravel, clay). One last requirement is that our device needs to be something that will be easy for Haitian people to use.

What is required to build this product?

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Building and Testing Prototypes

Goal
Using the Water Transportation System Competition Rules OR Water Filtration Testing Guidelines, student groups choose a design, research ideas, start building models/prototypes.

Outcome
Solidify design, select and “order” materials, and plan model building.

Description
This lesson is to take place over the next 3 or 4 weeks giving students time to research and build models/prototypes.
In this activity, students begin to make their ideas tangible—going from what's in their mind to things in their hand. They begin to think about and construct **models or prototypes** of their invention.

Key Concepts
Both models and prototypes are constructions that determine if a design or components of a design will work in both form (how does it look and feel) and function (does it work?). Both models and prototypes are used to:

- Test and trial a concept.
- Test and trial the way something looks or feels to the user.
- Try out dimensions and fit between components.
- Test a mechanism or subsystem of a design.

Models tend to be smaller in scope than prototypes; they are not as concerned with representing a final product in functionality, size, materials, and scope

Glossary
A **patent** is granted to the inventor by a country's government, and it gives the inventor the right to make, use, and sell an invention for a set period of time. In the United States, this time period is up to 20 years from the date the patent application is filed. Patents cannot be renewed. They may be extended through a special act of Congress under certain circumstances. You can search patents at the U.S. Patent and Trademark Office www.uspto.gov* to see if an invention has already been patented by someone else.

Trademarks protect words, names, symbols, sounds, or colors that identify goods and services from those sold by others. Trademarks can be renewed indefinitely. Some trademark owners use a TM (trademark) or SM (service mark) symbol to indicate that they are claiming rights to the use of the trademark. The Nike® swoosh is a familiar trademark symbol. The ® designation is used once a trademark is registered in the U.S. Patent and Trademark Office.

Copyrights provide the right to reproduce, distribute, perform, display, or license original writing, music, and works of art. Copyright covers the expression of ideas and not the idea itself.

Model: Models can be visual representations of a total design that is nonfunctional. Or, they represent some aspect (form or function) of a specific component.

Prototype: Prototypes tend to demonstrate some aspect of the design as a whole, either its form, function, or both.

More on Models and Prototypes
Models Plus
http://www.modelsplusinc.com/html/body_prototypes.html*
The company, Models Plus, Inc., has a nice display of prototypes. View prototypes for a Motorola cell phone and learn what materials were used to make the prototype.

More on Patents
U.S. Patent and Trademark Office
www.uspto.gov
You can search patent applications at the U.S. Patent and Trademark Office www.uspto.gov to see if an invention has already been patented by someone else.

Time
The model/prototype planning, building, and testing should take 3-4 (1.5 hour) sessions.

Supplies
A variety of materials to build models:

Suggested Supplies for Structure

- Recyclable materials such as soda bottles, wine corks, aluminum soda cans, bubble wrap, packaging peanuts, and twist ties
- Sample items (for students to acquire and use in larger constructions): PVC pipe and connectors, lumber (plywood and 2x4s) of different sizes
- Plastic buckets
- Fine sand
- Gravel
- Coffee filters
- Cotton balls
- Paper towels
- Straws
- Plastic hose
- Plastic garbage bags

Suggested Parts and Materials to Connect Things

- String, Wire
- Modeling clay
- Rubber bands
- Rubber tubing
- Tape (duct, masking, packaging, and electrical)
- Glues (epoxy, superglue, glue sticks, glues for hot glue gun, and rubber cement)
- Hinges
- Nuts and bolts, washers, assorted screws
- Nails, thumbtacks

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Preparation

- Have computers available for students to research their ideas.
- Gather the materials well in advance of this session. Send home information to parents and request donations of used building materials or any of the suggested recyclable items. Purchase what is not supplied or donated.
- On the day of the session, lay out the modeling materials organized by: a) things to build with, b) things for connecting and attaching, and c) the tools.

Procedures

Choose a project

1. Have students take out their Design Briefs, Meet the Client Worksheets, and Testing/Competition Guidelines. Remind them of the problem, design constraints, and client/user needs.
2. Give them time to brainstorm as a group and check in with you about their ideas.
3. Use your discretion on which items will be realistic and worthwhile for students to work on. As a rule of thumb, discourage work on things that will be exceptionally complicated or exceptionally simple, too dangerous or too controversial
4. Remind them that the final product should cost less than $20 and be made of as many locally available materials as possible!

Research

1. If you have a class set of computers you could have students research their ideas all at the same time. If you don't have a class set of computers you could rotate groups through as other groups work on models. You may want to do a patent search with some groups. Most will just Google their idea.
2. Have students record products that are similar to their idea in their research journals. They will need this information for the design brief.

Planning

1. Introduce the modeling materials. Explain, demonstrate, and answer students' questions about any unusual or unfamiliar materials or tools. Build a common vocabulary as you introduce and students study the materials.
2. While students are planning, talk with individual students and discuss their plans. It is important that students are intentional during the model building. They should have a purpose, something they'd like to test or trial in each model.

Materials and Construction

1. Students will be writing a final list of materials that they wish to use in their models/prototypes. They will hand in this list to you. Look over and OK the list before students start constructing their models.
2. Anything that they wish to use that is not provided will need to be explained and justified. Encourage students to see if they can get the item from home, but if not, then you will need to purchase the item for them.
3. Give students the time they need to construct their models/prototypes.

Testing

1. As students finish prototypes, they should test them and collect data.
2. For Water Transportation SystemProjects, please refer to the WATER TRANSPORTATION SYSTEMCompetition Rules. For Water Filtration Projects, please refer to the Water Filtration Testing Guidelines (below).
3. Prototypes should be redesigned based on the data they collect.

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Water Filtration Testing Guidelines

Goal
Students will test their prototypes for pH and turbidity. Their goal is to get the pH and turbidity of the "swamp" water as close to the EPA drinking water standards as possible.

Description
Water filtration inventions should be tested by comparing water quality before and after filtration. Students should be aiming to **improve** the quality as much as possible.

"Swamp" Water Recipe

Easy: 1 Quart of regular tap water
2 pinches of ground pepper

Medium: Everything in easy, plus ½ tsp of talc baby powder.

Hard: Everything in medium, plus 4 drops of green food coloring.

Procedure
Preliminary Testing
1. Have students measure the pH of tap water, distilled water, and pre-made "swamp" water. Record in data table (below). This will give them some baseline data to test against.

Prototype Testing
2. Once students have a functioning filter, have them test the pH (using test strips) and turbidity (using a Vernier turbidity meter) of the filtered water. Record in data table.
3. You may choose to have students measure flow rate as well. Simply measure the amount of water filtered in a particular time period. Keep in mind that a high flow rate is not necessarily a good thing. Often, filters that have a lower flow rate do a better job at filtering out contaminants.
4. Students should make modifications based on their data, and retest. This process of redesign and retesting can continue as long as time/student interest allows.

EPA Standards for pH and Turbidity

The EPA standards for drinking water require turbidity less than 5 NTU.
The EPA standards for drinking water require a pH between 6.5 and 8.5. Low pH results in bitter metallic taste and corrosion. High pH results in a slippery feel, soda taste and deposits.

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Environmental Protection Agency Standards

The EPA says that drinking water in the USA must have a turbidity less than 5 NTU and a pH between 6.5 and 8.5. Compare your results to those standards!

Water Filtration Data Tables

Team Members ____

Name of Device __________________________

Preliminary Data

	pH	Turbidity (NTU)	Observations	
Distilled Water				
Tap Water				
Easy "Swamp" Water				
Medium "Swamp" Water				
Hard "Swamp" Water				

Testing Data

Sketch	pH	Turbidity (NTU)	Flow Rate	Observations	
	Modifications:				
	Modifications:				
Description:					

Poster Board Design

Goal
To create presentation boards for the Invention Family Night.

Outcome
Students summarize their projects on presentation boards. This work party gets students started on their presentation boards for the Invention Family Night. In the process, students learn some graphic design principles.

Time
This activity is estimated to take 1 – 2 (1.5 hour) sessions for students to discuss and prepare their boards

Supplies
- 3-panel display boards
- Scissors
- Colored paper
- Scrapbooking double sided tape
- Markers
- Scrapbooking supplies
- Glue sticks
- Other art materials

Computer access is highly recommended in this activity!

Preparation
- Gather materials
- Reserve computer labs/laptops
- If possible, tell students to bring things they may want to put on their boards (i.e. special paper, etc) a few days before
- Read through student handout

Procedures
1. Each student (or project group) should be given a 3-panel display board.
2. Before beginning the display boards, suggest that students create a mock-up version to follow.
3. Discuss the purpose of the display and what should be included in it:
   - Written pieces on the board:
     - The Design Challenge
       - A brief description of the challenge/problem they solved
     - Background Information
       - A description of any current products (if any) that do similar things and how the product improves on them
       - A description of a typical user (a user profile)

- Features
  - A description of your solution, how it works, what things it does, and how it solves the challenge/problem
- Technical Drawings
  - Drawings, sketches, etc that detail how the finished product will look
- Product Requirements
  - A description of the basic requirements that will best suit the proposed product. Describe the quality (for example: flexible or sturdy), and the type of materials (for example: metal or plastic.)
- Data and Analysis
  - Students should include any data they collected while working on this project, along with an analysis of that data.
- Optional:
  - Students can have photographs, charts, or other information that is relevant to their project displayed

- Their model will be on display in front of the board. Their design notebook will also be on display in front of the board as another resource for parents/judges to look through

4. Remind students that during the Invention Family Night, they will need to stand by their board and answer questions about their projects
5. Now, have a work party for students to begin working on their displays. It is useful to have computers and printers available to make charts, do word processing, and so forth. You may need to show students how to make charts (if necessary).
6. Optional: If you have time before the Invention Family Night, you can have a mock-fair where students can practice answering questions and/or presenting their boards

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How Should the Board Look?

When designing your presentation board, it is important to keep in mind several design principles. Attention to the principles of graphic design will make your presentation more exciting and easier for others to use. Good design should attract viewers' attention to your project, and then guide their understanding of the information you wish to tell them.

Consistency

- Establish a style for your display and stick to it. Too much variation will make your display seem disjointed. Be consistent with all the elements.

Clarity

- Make sure your message is clear. Think about the clarity of your visual presentation. Is it cluttered? Question any possible unnecessary elements like cute stickers, doodles, patterns, etc.

Attention to Detail

- Judges/Teachers/Parents will notice if a display has grammar and spelling errors. Get people to proof-read your work.
- Make a checklist of the points you want to cover in your display and double-check that you present each.
- Make sure all your pieces are cut out with straight lines (use a ruler) as this will make your presentation look more polished and professional.

Elements of Your Design

Color

- Limit your display to two or three colors. Use tints and shades of these (for example, if you want to use green, you can use light green, dark green, etc and it's still one color). A large number of colors make designs seem less planned and inconsistent.
- Determine how color will be used and why. For example, you might want all your headers to be one color and text blocks to be another, so the headers will stand out.
- Keep in mind that different colors have different meanings and a power of their own. For instance, red usually demands attention. It can be used effectively for this purpose, but only if used in moderation. Too much red can be overwhelming and too bright.

Type

- Pick only one or two fonts for the text so your display will look consistent and unified. A large number of fonts, like too many colors, can be confusing.
- Decide on one or two techniques for emphasis in your type style. Some possibilities are: **bold**, *italic*, ALL CAPS), color, and choice of font.
- Don't use underlining if you have *italic* available. Underlining was designed to represent italic for typing since typewriters don't have italic.
- Avoid writing words vertically (with the letters stacked) as this will minimize readability.
- All caps are less readable than standard text, so if you choose to use them, do so only with small quantities of text, such as titles.
- Narrow columns of text are easier to read than wide columns of text. Left-justified or full-justified text is easier to read than centered text (for longer items).

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Invention Family Night

Goal
Learn what is needed to participate in an event to showcase their inventions.

Outcome
Students plan and participate in an Invention Family Evening (an informal fair of their inventions) for their chapter.

Description
Students learn more about the event that they will be participating in. Have students form committees that are responsible for some aspect of event planning.

Time
This activity will take approximately 40 minutes

Materials
None* - If students wish to make individual invitations for parents, ambassadors, etc, have materials available (construction paper, scissors, glue, markers, etc)

Preparation
- Begin to plan event
- Check with Administration/Staff/Teachers to get ok for the fair
- Select a date for the fair
- Select a venue
- Read through the student handout
- Decide if students will be doing presentations along with their boards
- Decide if you wish for student committees to help plan the event

Procedure
1. Discuss the format of the event, including the time, length, and location—these may be predetermined.
2. Explain the purpose of the event:
    a. To recognize students' hard work and celebrate their accomplishments
    b. To share engineering expertise with others
    c. To practice presenting projects to an audience
    d. To get feedback on their projects: display boards, models, and presentations
    e. To participate in a service project
3. Consider inviting a keynote speaker to the event. This might be a community figure or an engineer, for example.
4. Students might like to make individual invitations for family, friends, and their ambassadors. Have the details of date, time, place, and duration of the event on display for them to copy.
5. Optional: You can have students prepare a short presentation of their project as well as a board to display
    a. A chalkboard or chart pad in the presentation area should be set up so students can write or illustrate key points of their presentation as they talk. Or, you can make a computer slideshow, with a few slides for each student. The slideshow can serve as a

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backdrop for each student during his or her presentations. It might include a drawing or photograph of the design, design specifications, or other information that supports the presentation.

b. Assign photography duties to a parent volunteer, and ask that they photograph each student during presentations.

Student Committees

For more efficient planning, divide students into the following recommended committees to plan the Solutions Showcase.

- **Logistics**: This committee is responsible for room layout, student assignments/rotations, organization, prizes, and food.
- **Advertising**: This committee is responsible for promoting the event. This may take the form of flyers, newsletter/newspaper articles and advertisements, posters, emails, or a bulletin on the school TV network.
- **Engineering activities (optional)**: This committee is responsible for selecting and structuring the engineering activities for the visitors. These may include scaled down versions of some of the activities done during MESA, such *Build a Better Paper Clip*, or a *SCAMPER* activity. Younger students may want to choose some activities from the PBS program, Zoom Into Engineering*, www.asce.org/150/zoom.html*. This group is responsible for getting the material list to the leader.
- **Passport Scavenger Hunt (Optional):** This committee is responsible for planning and creating the Passport Scavenger Hunt. A passport is given to each visitor and includes specific questions about each project. When the visitors ask the questions, they get a stamp from each project. Each visitor with a complete passport gets a prize. This group will need to collect and compile questions from all the groups. If there will be different age groups of students at the fair, they may need to prepare different age-appropriate passports. They can get creative with the passports—include photographs of the projects, and so forth.

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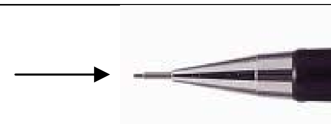
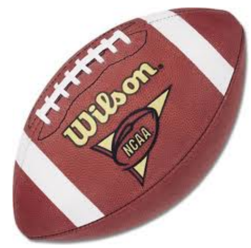
Comparative Size Chart

Item	Particle Size in microns (1 micron = 0.000001 m)	Comparing to everyday things-Each item is magnified by 500,000 times!	
Viruses	0.005 – 0.3	.5 mm pencil lead	
Dye Particles	0.1 - 10	25 mm/ 1 in wide pink eraser	
Bacteria	0.3 – 60	150 mm/ 6in football	
Talc Powder	0.5 - 70	150 mm / 6in football	
Fine Sand	20 - 300	0.8 m/ 32 in width of a bedroom doorway	
Coarse Sand	300 - 2000	6m/ 20 ft about the length of a minivan	
Small Gravel	2000 – 16000	50m/ 165 ft would just fit under the Fremont Bridge	

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