



MESA Advisor Facilitator Guide

Water Transportation

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.

Rube Goldberg (2 sessions)	4
Students work in groups to build a Rube Goldberg machine that will perform a specific task.	
Straw Towers (1 session)	11
Students work in groups to build the highest tower out of straws and tape.	
Heat Shield (1 session)	12
Students design a model of a heat shield for a space ship.	
Build a Better Paperclip (1 session)	13
Students experience the Engineering Design Process by redesigning a simple, everyday object.	

Water Transportation

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

Session 1: Introduction to the Problem/Building Empathy	17
A. Students will participate in a relay race to transport water through an outdoor course of your design.	
B. Students will watch videos of people around the world transporting water to gain an understanding of why the project is important.	
C. Students will calculate water usage of their household.	
D. Students will watch q drum video to see one solution to the problem.	
Session 2:	
SCAMPER	20
A. Students will use the engineering design process to scamper a 5 gallon bucket to their situation.	
B. Students will present their situation and their solution to the class.	
Session 3: Meet the Client	26
A. Students will meet the client through video. The problem will be presented to them and they will fill out a meet the client worksheet.	
B. Students can research what solutions there are to the given problem. It would be great if you had access to computers.	
C. Students will be introduced to the Water Transportation contest for MESA day.	
D. Students will begin to fill out a design brief.	

Session 4 through Completion: Water Transportation Inventions.....28

- A. Students will finish the design brief.
- B. Students will build their Water Transportation System in groups.
- C. Students will collect data, calculate calories used and improve upon the design.

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!

Poster Board Design (allow at least 3 sessions)43
Students create a poster board that outlines their Water Transportation/Filtration Invention.

Invention Family Night.....46
Students Water Transportation/Filtration Inventions and poster board displays are shared with their families.

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.

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](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](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:

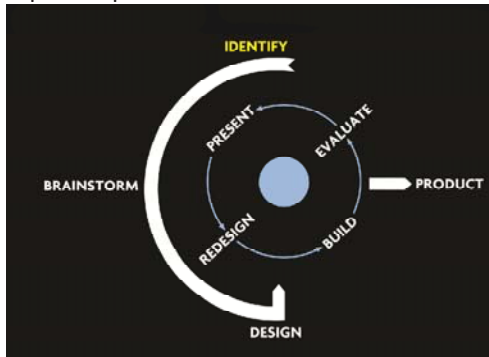
There are numerous computer games out there that mimic Rube Goldberg machines for students who may be interested. Some are older games, but can still be purchased on Ebay or other online stores. One such game is “The Incredible Machine.”

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.
- Never 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.

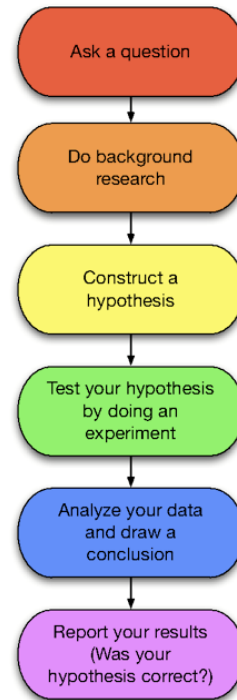
Design and Develop – Create a final sketch of the best design solution. Then, materials needed to construct the new product are identified and the new product is built.

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.

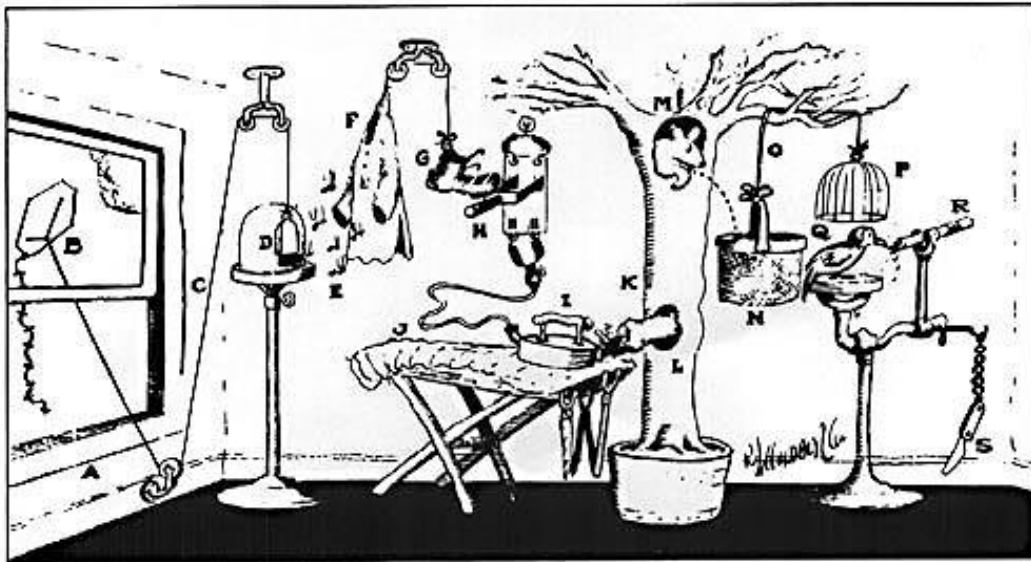
The **Scientific Method** is a series of steps that allows people to develop and test a question.

The Scientific Method



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."

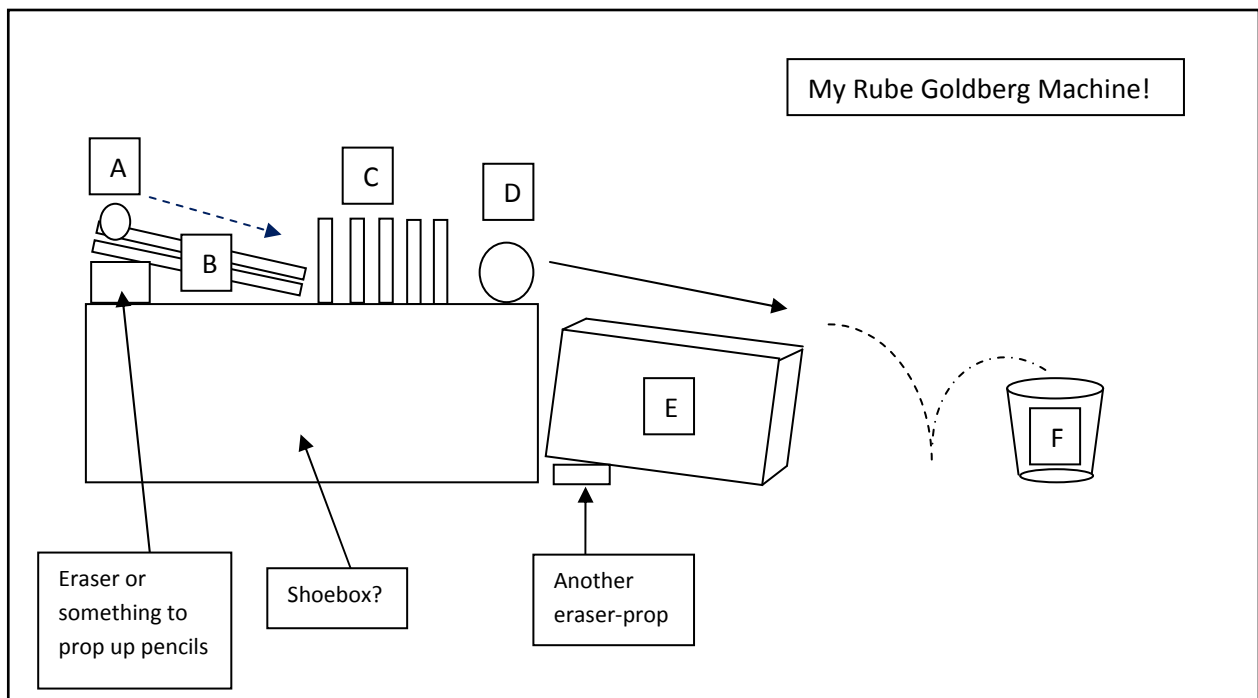
The Problem: Your job during this activity is to make a "machine" that will perform a task. Your machine should have between 3 – 5 steps. Your MESA Adviser will explain what task your machine is to perform.

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

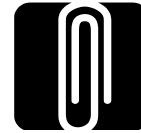
1. Explain the purpose of the activity to the students and then distribute the materials. Inform them that the free standing straw tower that is the tallest is the winner.
2. After 45 minutes, announce that time is up. Measure the height of each of the towers and determine the winner.

Heat Shield Design Activity

For details and materials about this activity, please visit our website.

http://oregonmesa.org/advisors/?attachment_id=166

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.

Each 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

Additionally:

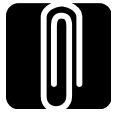
- Be sure that each group of 4 students has one pair of needle nose pliers and several examples of paper clips
- Set up wire cutting station - put goggles and wire cutters in the same place.

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

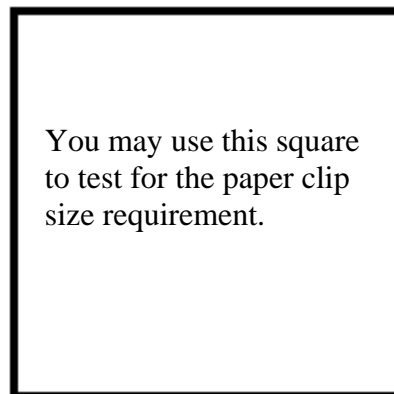
- Your paper clip must be unique. It cannot look like any paper clip you have ever seen before, but it may have features of other clips.
- It can be no bigger than 2 inches by 2 inches (5 cm x 5 cm).
- It must hold 10 pieces of paper together.
- You may use other materials to enhance your design, but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



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

The Race Is On!-Teacher Guide

Developing empathy for those who have to carry their own water

Goal

Get students thinking about water usage at home and around the world.

Outcome

Students will calculate personal water usage and be exposed to water transportation issues.

Description

Students start the meeting with a water relay race to show them how difficult it is to transport water. They then see video clips (Water Transportation Site) of others transporting water across different terrains. To wrap up the lesson students calculate their personal water usage.

Supplies

- One 5 gallon bucket for each group of 3-5 students.
- Student water usage worksheet.
- Prizes for the winner of the race – and snacks for everyone.

Safety Guidelines

Monitor students as they carry the water – give guidelines on how to safely carry water.

Procedures

Race

1. Set up a place for a relay race in a grassy field. Set one set of cones for each team about 100 meters apart. Make sure teams are well balanced (don't have a team of football players vs. the chess club). For additional challenge you may include obstacles in the course – having them go over playground equipment, etc.
2. Have each team fill their bucket and line up as a team at one end of the field. When you say go each teammate must go down the field around the cone and come back carrying the water. When each teammate has carried the water they are finished.
3. Determining the winner. Don't tell students in advance how to win. Let them think it is the fastest group. The winner of the race is the group with the most water left in their bucket.

Video

1. Encourage students pay careful attention to the obstacles the different people have to overcome as they transport water. Have discussion about what it must be like to go through that hassle for collecting water. Also discuss how they would have to limit their water usage if they had to collect water in that way.

Worksheet

1. Handout water usage worksheets. Have student give their best guesses and calculate how many buckets of water would be needed for their household.
2. Have students take home the worksheet to complete it with greater accuracy. Have rewards for those who completed the worksheet the following week.

Video

1. Show video from Qdrum website: <http://www.qdrum.co.za/> (also available to view on youtube: http://www.youtube.com/watch?v=XQ_n5y3-Xnk)
2. Encourage students to think about new water transportation ideas for developing nations.

Wrap Up

Each student presents a brief explanation and demonstration of his or her paper clip design.

Water Transportation

Saturday Water Usage of the _____ family.

Use the table below with your best guesses to calculate how much water you family uses.

Activity	Number of times	Gallons used	Water Used (# of times x gallons)
Baths		40	
10 minute Showers		20	
Teeth Brushing		1	
Hand/Face washing		1	
Shaving		1	
Dishwater		20	
Dishwashing by hand		5	
Laundry		10	
Toilet Flushes		3	
Glasses of water		.0625	
30 min. yard watering		60	

Total Usage: _____

Gallons per family member = Total Usage / number of family members

Buckets per household = Total Usage / 5

Take this worksheet home and collect more accurate information, bring it back next week.

Activity	Number of times	Gallons used	Water Used (# of times x gallons)
Baths		40	
10 minute Showers		20	
Teeth Brushing		1	
Hand/Face washing		1	
Shaving		1	
Dishwater		20	
Dishwashing by hand		5	
Laundry		10	
Toilet Flushes		3	
Glasses of water		.0625	
30 min. yard watering		60	

Total Usage: _____

Gallons per family member = Total Usage / number of family member.

Bonus: Ask your parents to look at the last water bill and calculate gallons per person per day

SCAMPER – Teacher Guide

Goal: Introduce and practice SCAMPER, a creative technique for improving existing designs. Students doing Water Transportation System(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

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

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.

SCAMPER (Water Transportation System) Client Cards

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

Konson Woreda, Ethiopia

April 2009

In a land where water is scarce, communities will come together to do whatever is necessary to find much-needed water. In the Konso Woreda of Southern Ethiopia, this community initiative was taken to a whole new level when a village built and maintained a mile of road, just to allow a drill rig access to their community. Due to the hydrology of the region, drilling a well where the road originally ended was not possible, but there was hope that drilling a mile further down the hillside would work. The community came together and, using only farm tools, cut a dirt road into the hillside, allowing access for the large drill rig.

When Blood:Water Mission visited the newly-drilled well, the community was out fixing a section of the road washed out by a massive rain storm the day before. While the labor to maintain the road was hard, the people were laughing and talking as they worked. When asked why they were so happy, the instant response was, "because at the end of this road, there is water."

Modify your bucket for a two mile walk down a rough road.

Cyanika, Rwanda

In Northern Rwanda, people walk long distances from their homes on mountainsides to the springs and lakes in the valleys to find water. This process often leaves families with very little water for their daily needs and yet consumes much of their time and energy.

Venantia is part of these community groups. "I walk from 6 am to 4 pm and come back with 20 liters of water which is not enough for my family."

Modify your bucket so that is easier to carry down the mountain side. Think of ways that bucket modifications might make the trip go more quickly.

Garin Dan Dela, Niger

What if it was your job to get clean water for your family? What if the closest place you could find that water was in another village, three miles away, in another country?

That's exactly what Maria Oumarou, 12, had to do before World Vision built a water pump in Garin Dan Dela, Niger, in December 2008. She had walk over three miles to cross the border into Nigeria just to get clean water for her family.

Maria still remembers that she had to wake up before 6:00 a.m. to fetch water. By the time she carried the water containers home from the other side of the Nigerian border, it was almost noon.

Maria's biggest concern was not the fatigue, nor the pain she felt in her thin arms. "I feared that if I missed another morning in school, I'd soon be unable to catch up with my class," says Maria. "I really didn't like missing so much in school."

Modify your bucket so that it is easier to transport water on this 6 mile journey. The region is not fairly flat but the roads are not paved or well maintained.

Port-au-Prince, Haiti

Prior to the quake, about half of Haiti's urban population had access to tap water, according to a 2006 demographic and health survey conducted by the World Health Organization and UNICEF. Since the quake, community kiosks selling water have been replaced by water trucks and boreholes where children fill buckets to the brim and carry them, carefully balanced on their heads, back to their tents. The United Nations WASH (Water and Sanitation) cluster says relief efforts now meet the water-supply needs for 1.2 million people.

Modify your bucket so that is easy for a child to manipulate through a crowded camp. Assume that they will be stepping over many obstacles and navigating through narrow paths.

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 on the MESA website). 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 appropriate for your invention topic (Water Transportation or Water Filtration)

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!

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 _____

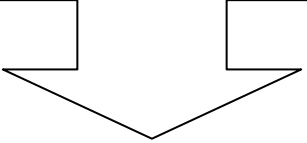
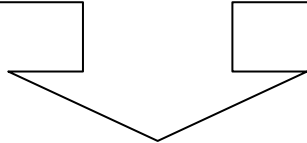
What is the problem?
What is your client's design challenge?

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!

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 .

- 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).

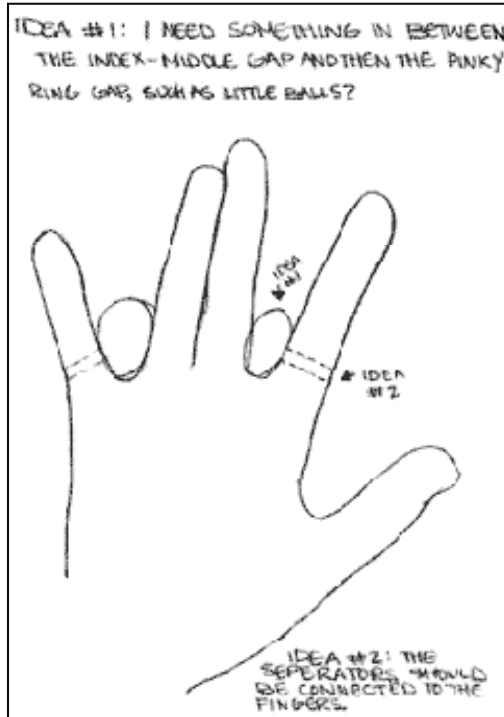
Example design brief: Bass Space (patent pending).

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.

Design Brief – Water Transportation

The Design Challenge

The problem is that many people in the world have to walk several kilometers to get their water.

Our challenge is to design a product that could be used in Uganda to transport water. Our product needs to be affordable for the family and decrease the amount of energy it takes to move the water.

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

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

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 Uganda. Our device must be easy to use on the hilly rough roads that on which they will have to transport the water.

What is required to build this product?

Building and Testing Prototypes

Goal

Using the Water Transportation System(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*](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

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 System Projects, please refer to the WATER TRANSPORTATION SYSTEM Competition 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.

Building the Water Transportation System-Teacher Guide

Using the EDP to create a water transportation system

Goal

Have students use the EDP to create a water transportation system. Students will need to collect and analyze data to improve their project.

Outcome

Students will build a Water Transportation System that would be sustainable for the client.

Supplies

- Materials that would be available to the client. Other materials.
- Notebooks.
- WATER TRANSPORTATION SYSTEM rules for MESA day.
- Calorie calculation worksheets.

African Supplies

Many building materials would be available to our client.

More common materials include:

- Jerry cans
- Metal buckets
- Fabric

Less common materials include:

- Rope
- Plastic pipes
- Plastic buckets
- Old tires
- Bicycles

Materials rarely used:

- Wood
- Small wheels (wagons, wheel barrows, etc.)

Project Note

Currently most of the people in Uganda and Sudan use Jerry cans and metal buckets to transport water. Some people use bicycles to transport water – they ride to the source and then push their bikes back with the water loaded on it. If they live in an urban area they will walk 2km round trip to get water on average. If they are rural they walk 8-9km round trip on average to get water. Women and children are responsible to get the water. Women often carry two full Jerry cans of water on the journey.

If a new way of getting water was introduced, it would be best received at an orphanage. Orphanages are used to getting outside help and are more willing to try new ways of doing things. From there others in the community may want to try the new method of getting water – if it was successful.

Procedures

Use the EDP to create a WATER TRANSPORTATION SYSTEM that fits within the parameters of the contest guidelines.



MESA DAY CONTEST RULES 2011

Water Transportation System

LEVEL: Middle and High School

TYPE OF CONTEST: Teams of 3-4 students

OBJECTIVE: Students will create a Water Transportation System(WATER TRANSPORTATION SYSTEM) to move up to 18.9 liters (5 gallons) of water 500 meters through an obstacle course.

Materials

1. Hazardous materials may not be used in the construction or operation of the device.
2. All other materials to build the device are legal and optional. Materials readily available to the client in Sudan are preferred to other materials.

General Rules

1. Teams must design, build and operate their own WATER TRANSPORTATION SYSTEM. This device will include all parts necessary to move up to 18.9 liters of water through the course.
2. The maximum cost of this project is \$20. Projects may be disqualified if the judge feels that the WATER TRANSPORTATION SYSTEMwould cost more than \$20 to reproduce.
3. Score will be based on quantity of water, calories needed to transport water, cost of system, percentage of local supplies, and overall design.

Course Configurations

1. The course will remain as an unknown until MESA day.
2. The course will include inclines.
3. The course will include obstacles that you will need to go over, through, or around.
4. Total length of the course will be approximately 500 meters.
5. Buckets or a hose will be available to fill the WATER TRANSPORTATION SYSTEMat the start of the course.
6. Device will have to be emptied at the end of the course.

Test Configurations

1. Calories needed for a 60kg female to use the WATER TRANSPORTATION SYSTEMover 1 km will be calculated according to the worksheet.
2. Fifty pound fish scales will be used to calculate forces needed for the system.

Scoring Guidelines

1. Quantity of water. 100 points. Each liter of water that reaches the end of the course is worth 5.25 points. Maximum of 100 points possible.
2. Calories needed for client to transport water. 100 points. Using the following formula based on worksheet (C = calories used, L = least calories used from all groups entering the contest, P = point awarded, Q = quantity of water score).

$$P = (L/C) \times Q$$

3. Design. 100 points. A judge will assign up to 30 points to your device based on user friendliness and projected longevity. You can earn up to 35 points based on the estimated cost to reproduce your product. Up to 35 points will be awarded for using supplies that are readily found in Africa.
4. Notebook bonus. 50 points. The team with the best notes and data tables will receive 50 points. Second best - 40 points. Third best – 30 points. Every other team with useful notes – 25 points.

Safety

1. Students must operate their device in a safe manner.
2. Students may not interfere with other teams on the course.

Operation

1. Each device must be ready for competition when called.
2. Each team will be allowed only 1 time through the course.
3. Teams will have 5 minutes to fill their device.
4. Teams will have 15 minutes to complete the course. Only one student will be allowed to transport the water. The other team members may encourage and coach the student transporting the water.

Awards

1. Middle School awards given to top three teams
2. High School awards given to top three teams

Water Transportation Data Table

Team Members _____

Sketch	Empty weight (N)	Full weight (N)	Volume (l)	Distance to Center (m) – Carrying design	Sustained force (N) – Rolling /Dragging	Calories Used
						Trial 1 Trial 2 Trial 3
Modifications:						
					Trial 1 Trial 2 Trial 3	
Modifications:						
Dimensions					Trial 1 Trial 2 Trial 3	

Newtons = ____ lbs x 4.45

Sustained force = reading on scale as WATER TRANSPORTATION SYSTEM is being pulled.

Distance to center = distance from center of person to center of WATER TRANSPORTATION SYSTEM. If device is balanced, distance to center = 0.

For evaluation of water transport design

Given Assumptions: For evaluation purposes the design will be moved by a 60 kg, 1.6 m tall human female.

Design Goal: An individual person must carry/move the maximum amount of water up to 5 gal (17.9 L) over the given terrain profile.

Use the following worksheet to evaluate your design.

I) Determining Weight:

1. Put the empty apparatus on the scale and measure the weight.

_____ lbs

2. Fill apparatus with plain tap water.
3. Put the full apparatus on the scale and measure the weight.

_____ lbs

4. Convert the number in Step 3 from lbs to Newtons (N) by multiplying it by 4.45 N/lb.

_____ N

II) Determining Design Type: Choose which best describes your design.

- A) Carried Load: No portion of the apparatus touches the ground during transport
- B) Dragged Load: Apparatus is in constant contact with the ground during transport and point of contact slides along the ground.
- C) Rolling Load: Apparatus is in constant contact with the ground, point of contact rolls along the ground.

III) Complete one of the following sections.

For carried loads complete only Part A and move on to Section IV.

For dragged loads or rolling loads complete only Part B and move on to Section IV.

A) Carried Load

Carried loads are typically held against or as near the body as possible, but there is still some distance between the center of the body and the center of the carried load.

1. Measure the width of the apparatus from the side nearest the body to the opposite side. (See examples below)

_____ meters

2. Divide the number in Step 1 by 2.

_____ meters

3. To accommodate the width of the body add 0.2 meters to the number in Step 2.

_____ meters

4. Multiply the number in Step 3 by the full apparatus weight that was found in Section I, Step 4.

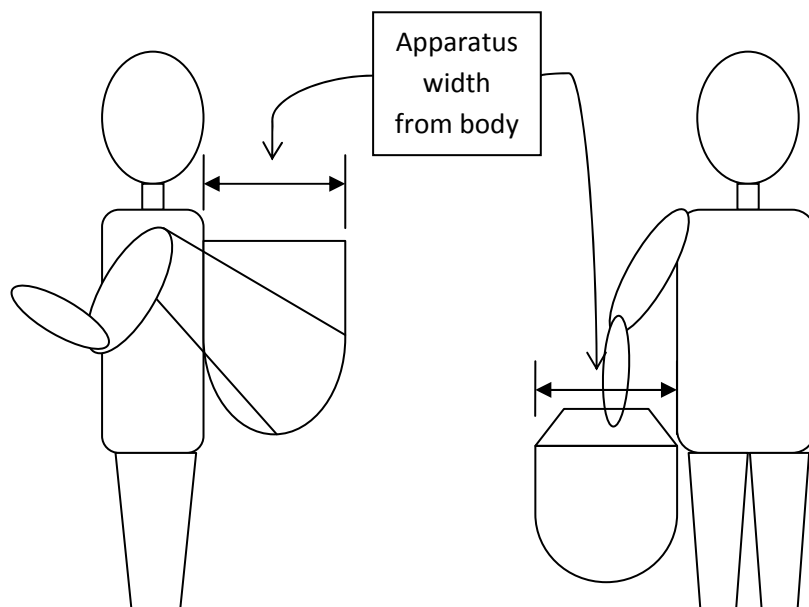
_____ meters*N

5. Divide the number in Step 4 by 0.2 meters. Your answer is the equivalent carried load.

_____ N

6. To account for body weight, add 600 N to the number found in Step 5. Your answer is the total force (W) used in Section IV to compute kcal used.

_____ N



B) Dragged or Rolling Load

Dragged or Rolling loads touch the ground during transport and thus the person moving the apparatus must overcome the effect of friction. To measure the induced friction force:

1. Attach the hanging type scale to the handle of the apparatus.
2. Hold the scale at a height of approximately 1 m.
3. Holding on to the scale as a handle, walk a distance of 3 meters at a constant speed while reading the force measured by the scale.
4. Record the force measured.

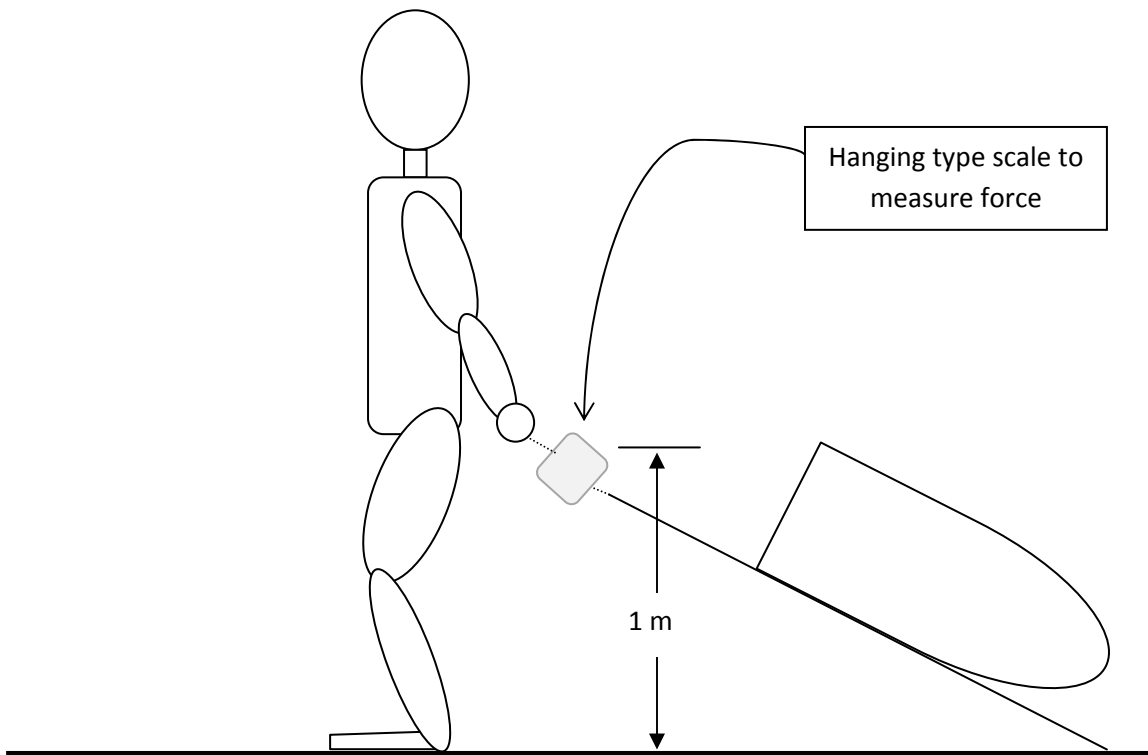
_____ lbs

5. Convert the number in Step 4 from lbs to Newtons (N) by multiplying it by 4.45 N/lb.

_____ N

6. To account for body weight, add 600 N to the number found in Step 5. Your answer is the total force (W) used in Section IV to compute kcal used.

_____ N



IV) Determining the Calories Used For All Design Types

IV) Determining the Calories Used

From research done in 1977 by the US Army, there is a relation between the load carried and the calories (kcal) used. For a 600 N person walking at a rate of 4.8 km/hr (3mph) for one hour, the equation can be reduced to:

$$Kcal\ used = 77.4 + (5.1 * 10^{-7} * W^3) - (6.08 * 10^{-4} * W^2) + (3.27 * W)$$

Where W is the total force in Newtons (N) found in Step 6 of Part III.

Kcal used = _____

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

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).

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

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.