Post Lesson: Teacher's Guide
Engineers and the Engineering Design Process

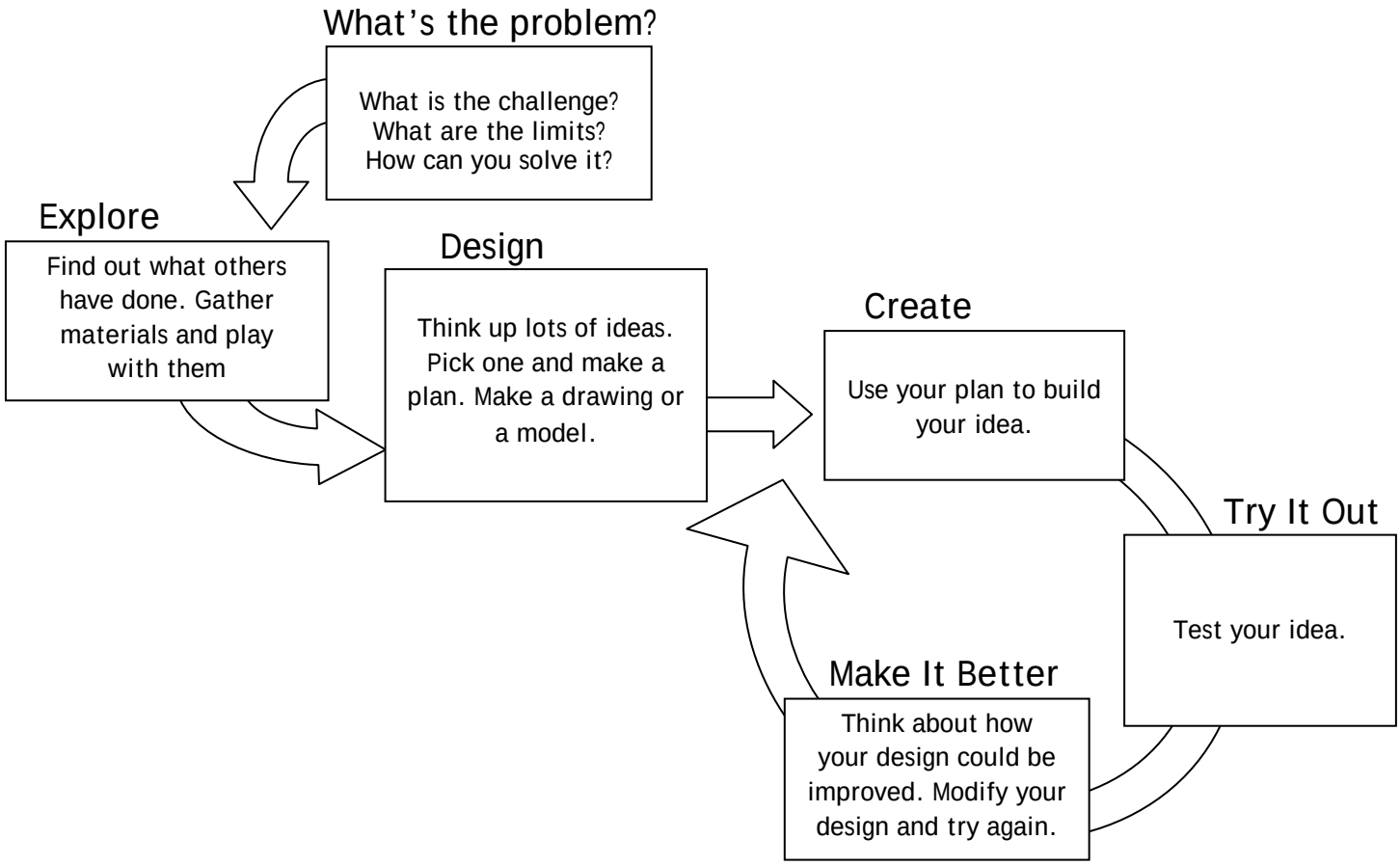
This post-visit lesson consists of three activities, designed in such a way that they complement each other, yet each can stand alone. You can choose to do as many or as few as you wish, depending on the needs of your class.

1 On the first page of the student activity document, the students are presented with a chart of the engineering design process. The names of the steps are given in the proper order, but the boxes for the descriptions are left blank.

The objective is for students to use knowledge and reasoning to identify which description corresponds with which step, and to write out each description in the appropriate box. This helps reinforce the terminology used in the new Minnesota Science Standard 6.1.2.2.1 and reinforces the idea of a step-by-step design process.

We are referring to these steps as "the engineering design process," but in fact, this system can be used for all types of creative problem-solving, from the arts to psychology. The skills learned in engineering are useful in many facets of everyday life.

Answers are given below:



2 The second page is designed for students to exercise their creative problem-solving skills. In essence, they are using the first few steps of the design process as defined by Minnesota Science Standard 6.1.2.2.1: *Identify the problem* and *make representations*. To go beyond that requires actually making their contraption, which would perhaps take more time than you can spare in your class, but they can do some preliminary *evaluation* even without building the device.

In doing this activity, students might need more guidance than they get from the instructions. A good way to offer support is to ask specific, thought-provoking questions that don't have a "right" answer in mind.

For example, suppose the student has chosen to solve problem B: "You are going on vacation and can't find anyone to water your plants while you're gone. You need a device that will give your plants the right amount of water – not too much and not too little."

During the *What's the problem?* step, you could ask questions like this:

- How much water does a plant need?
- How often does it have to be watered?
- What are some ways people move water from place to place?
- Could you use gravity, electricity or another force to help you?
- What are some containers you've seen water in?

During the *Design* step, you could ask questions like this (referring to the student's drawing):

- How does it work?
- What material is this made out of?
- How does this connection work?
- How does this fit together?
- How big is this part?

You may find that some students excel at this activity, while others struggle to generate any ideas at all. Creativity is a difficult skill to teach. At The Works, we believe the best approach is to give students as many opportunities to flex their creative "muscle" as possible, even if the results are meager at first. Creativity is a skill like any other; it takes time to develop it!

The following is a quick and easy hands-on project that allows the students another chance to engage with the design process, especially the final steps of *Try It Out* and *Make It Better*.

Clay Boats

Materials: Ball of modeling clay for each student – 1.5 to 2 inches in diameter
Large bins or buckets filled with 3+ inches of water
A couple dollars worth of pennies

The objective of the activity is to construct a boat that (a) will float, and (b) will hold a large number of pennies – the more, the better!

1. **What's the problem?**. In a class discussion, What's the problem? or challenge and list the constraints. The challenge, as stated above, is to construct a floating boat that will hold as many pennies as possible. Constraints include the fact that the only available material is a small ball of clay, hands are the only tools, etc.

2. **Explore**. Part of this step includes discovering what others have done. With your class, you can discuss the shape of existing boats: they typically have flat or slightly rounded bottoms and high sides. Why? What would happen if boats had a different shape? Students will get a chance to discover for themselves in a few moments.

3. **Design**. If you wish, you can have your students sketch the boat they plan to make, or they can verbally describe their ideas to you or each other.

4. **Create**. Each student forms their ball of clay into the shape they designed.

5. **Try It Out**. Students can test their boats in the buckets or bins of water. If a boat floats, student can add pennies one at a time until the boat sinks.

6. **Make It Better**. This activity offers a terrific opportunity for evaluating the solution and modifying the design. Most clay can be reformed again and again, even when wet, until students find the boat shape that works the best.

Elementary Engineering Curricula and Resources

Compiled by The Works

ASEE: American Society for Engineering Education. Useful curriculum ideas and terrific links. Great pamphlet called "Engineering: Go for It." http://egfi-k12.org/

Design and Discovery is a comprehensive inquiry-based curriculum, which introduces students ages 11-15 to engineering through design. In 18 sequential sessions, students follow the design process, from identifying a design opportunity to developing a working prototype. Free to download from Intel. http://educate.intel.com/en/DesignDiscovery/

Design Squad: This TV program produced by WGBH Boston features eight diverse high school students who tackle a series of intriguing and sometimes wacky design challenges for real clients in a fast-paced team environment. Not showing on TV in Minnesota, but you can download the episodes and excellent activity and educator guides from their website: http://pbskids.org/designsquad/

Also check out the elementary engineering activities on other PBS shows:

Zoom: http://pbskids.org/zoom/activities/sci/
Dragonfly TV: http://pbskids.org/dragonflytv/show/technologyinvention.html
Building Big: http://www.pbs.org/wgbh/buildingbig/

Engineering Education Service Center stocks books, supplies, movies & resources for teaching about engineering. www.engineeringedu.com

Engineering is Elementary (EiE): The Museum of Science in Boston is creating this research-based, standards-based, and classroom-tested curriculum that integrates engineering and technology concepts and skills with elementary science, social science and language topics. www.mos.org/eie

Future Scientists and Engineers of America (FSEA): Excellent elementary engineering kits that can be bought individually, or in quantity for after school programs**.** www.discoverycube.org/fsea.aspx?q=47

International Technology Education Association (ITEA) is the professional organization for technology, innovation, design, and engineering educators. Published "Standards for Technological Literacy," the inspiration for many engineering standards nationally. Great links and resources include e-newsletters, films, publications and an elementary curriculum called I^3: Invention, Innovation and Inquiry. www.iteaconnect.org

Pitsco: A catalog packed with engineering kits and materials. www.pitsco.com

Project Lead the Way: Comprehensive engineering curriculum for secondary schools, with new elementary lessons. www.pltw.org

Schoolyards to Skylines: Architecture lessons integrated with elementary subjects. www.architecture.org/aboutschoolyards.html

The Science Source: A favorite source of materials and books for hands-on engineering. Their catalog has a particularly good section of elementary engineering books from England. http://thesciencesource.com

Stuff That Works: Elementary engineering curriculum developed by the City College of New York. Download projects online or purchase curriculum books and resources. http://citytechnology.ccny.cuny.edu/Design_Tech.html

TeachEngineering.com is a searchable, digital library with standards-based curricula to teach engineering in K-12 settings. www.teachengineering.org Also see this related site: www.engineeringpathway.com/ep/index.jhtml

A World In Motion: Engineering challenges for elementary students. Curriculum and materials free from Society for Automotive Engineers. www.sae.org/exdomains/awim/aboutus

Local Organizations for Science and Engineering

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Bakken Library and Museum www.thebakken.org

BEST www.bestoutreach.com

Destination Imagination www.mndi.org

First Lego League/High Tech Kids www.hightechkids.org

KidWind www.kidwind.org

Leonardo's Basement www.leonardosbasement.org

Mad Science www.madscience.com

MN Planetarium www.mplanetarium.org

Minnesota Science Teachers Association www.mnsta.org

Minnesota Technology Education Association www.mtea.net

Pavek Museum of Broadcasting www.pavekmuseum.org

Science Museum of Minnesota www.smm.org

Science Outside the Box www.scienceoutsidethebox.com

SciMathMn www.scimathmn.org

SEEK: environmental education resources www.seek.state.mn.us

Starbase Minnesota www.starbasemn.org

STEPS www.stthomas.edu/engineering/outreach/steps/default.html

Tronix Team www.tronixteam.org

U of M Office of Outreach and Diversity http://it.umn.edu/students/dao

Urban Boatbuilders www.urbanboatbuilders.org

Young Inventor's Fair (YIF) www.successbeyond.org/YIF.htm