Designing the water treatment process

BY SUSAN GERMAN

The ongoing water crisis in Flint, Michigan, served as the inspiration for a design brief I created that asked students to explore the process of water treatment. A *design brief* is a written document between a client and designer that outlines the scope of the project and defines the final product. The design brief begins with a short background statement:

> *Metropolis City is seeking bids for its water treatment. There is more than one treatment facility in the area connected to the city's water distribution system.*

After reading the background statement, students read an article I created for the lesson (see Online Supplemental Materials). It is often easier to create your own article because many of those found in newspapers or magazines are above the middle school reading level, lack science, include science that is too technical, or are much too long.

The challenge statement, the next piece of the design brief, describes the task and engages students. There needs to be enough

FIGURE 1: Design brief

Large Metropolis City is seeking bids for its water treatment. There is more than one treatment facility in the area connected to the water distribution system of Large Metropolis City. Large Metropolis City wants each firm to design and construct a model of their water treatment process. A sample of untreated water will be given to each firm to pass through the model. To determine improvement, each sample will be tested before and after treatment. Treated water must be clear in appearance with no odor, have a pH within 6.5 to 8.5, and a minimal conductivity result. Each company is restricted to the materials list: balance, conductivity tester, graduated cylinder, pH strips, plastic cups, newspaper, permanent marker, plastic water bottle, rubber band, cheesecloth, plastic wrap, waste container, utility knife, masking tape, paper clip, cotton balls, coffee filter, activated carbon, gravel, sand, uncooked macaroni, cardboard, plastic meat trays, alum, pool coagulant, jars, and panty hose.

Safety note: Do not drink the water or consume any item related to this project. Safety goggles must be worn at all times.

Further information: Disinfection of water requires the use of bleach, which is hazardous to use in the classroom. That said, just list what you would add to disinfect the water but do not attempt to disinfect the water as part of this activity.

Students answer the following:

1. Who is the client?
2. What is the final product?
3. What are the engineering constraints?
4. What are the criteria?
5. What tools are available for use?

detail so students know the goal of the task but not so much that a solution to the problem is evident. It needs to leave room for students to be creative problem solvers. Here's the challenge statement for the lesson:

> *Large Metropolis City wants each firm to design and construct a model of the five basic steps of the water treatment process. A sample of untreated water will be given to each firm to pass through the model. To determine improvement, each water sample will be tested before and after treatment.*

Criteria and constraints are the cornerstones of design briefs. Criteria provide the desired outcome of a solution. When students test a project, they often ask, "Is this good enough?" Criteria allow students to self-evaluate their work by defining *good*. Water treatment plants must meet certain criteria for water quality, which I discuss in the brief:

> *Treated water must be clear in appearance with no odor, have a pH within 6.5 to 8.0, and a minimal conductivity result.*

Engineering constraints include materials, cost, time, scientific principles, safety, reliability, aesthetics, and social, cultural, and environmental impacts. To help students understand the difference between constraints and criteria, say, "*Criteria* allow you to evaluate your project. They help you answer, 'How good is it?' *Constraints* prevent you from designing as you wish and often must be worked around."

ALL PHOTOS COURTESY OF THE AUTHOR

Students use recycled materials to evaluate the properties of the materials against what is needed for their design to work.

The last part of the design brief compiles tools and constraints into a list:

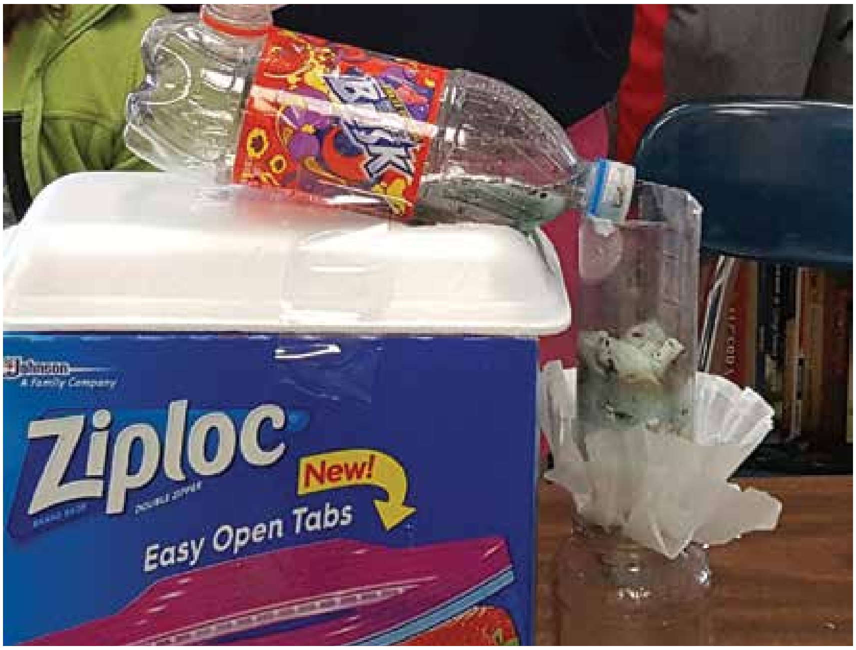
> *Each company is restricted to the materials list: balance, conductivity tester, graduated cylinder, pH strips, plastic cups, newspaper, permanent marker, plastic water bottle, rubber band, cheesecloth, plastic wrap, waste container, utility knife, masking tape, paper clip, cotton balls, coffee filter, activated carbon, gravel, sand, uncooked macaroni, cardboard, plastic meat trays, alum, pool coagulant, jars, and pantyhose.* (*Pool coagulant* is a chemical that causes particles in pool water to "clump" together.)

After students review the list, I ask them to distinguish tools from constraints to make sure they understand the design brief. See Figure 1 for the complete design brief, including a note about safety.

To create a "polluted" water sample, I mixed water, vinegar, food dye, dirt, grass, and leaves. As a class demonstration, I tested the water to provide students with starting levels of clarity, odor, pH, and conductivity. While drinking water is tested for several more criteria, these four are relevant to the curriculum and easy to test in the classroom. Visual assessment determines clarity, a sniff test evaluates odor, and a conductivity meter and a pH meter provide the last two metrics. By testing the polluted water, students can understand the effectiveness of their model immediately. In addition, students can understand how their water test would be performed.

Conclusion

The use of the design brief ensures students have all pertinent information related to the task. The result? Engaged students who are focused on solving a specific problem. ●



A student-designed water quality model.

ACKNOWLEDGMENT

I would like to thank Mariel Milano for her February 2016 presentation (Addressing Engineering and Technology in the Framework) to the Science Teachers of Missouri MODELS Program.

RESOURCES

Gooding, J., and B. Metz. 2007. Inquiry by design brief. *Science Scope* 31 (3): 35–39. *www.nsta.org/store/product_detail.aspx?id=10.2505/4/ss07_031_03_35.*

Safety—*www.nsta.org/safety*

ONLINE SUPPLEMENTAL MATERIALS

Article for the lesson—*www.nsta.org/scope1702*

Susan German (*sgerman@hallsville.org*) is a science teacher at Hallsville R-IV School District in Hallsville, Missouri.