ASME International

Engineering Magic

TRICK #4: The Magic Milk Pitcher

Teacher's Guide

Overview of the Trick:

A pitcher that appears to be full of milk is set on the table. The Magician takes a sheet of newspaper, shows both sides, and then forms it into a cone. The point of the cone is given a slight twist to create a receptacle for the milk. After apparently pouring milk into the cone, the Magician opens the cone to reveal that it is empty. To "prove" that the pitcher really contains milk, the Magician then pours milk from the pitcher into a glass.

How the Trick Works:

(Do not reveal this to students until after they have proposed their own explanation for the trick.)

The pitcher contains a transparent liner. Milk is injected into the narrow space between the liner and the wall of the pitcher, making it appear full. As the pitcher is tipped, a shield on the lip of the pitcher creates a barrier and the milk flows through a cutout in the liner wall into the liner instead of pouring into the cone. When the pitcher is tipped a second time, milk spills over the barrier and pours into the glass.

Lesson Focus: **Design Constraints**

Lesson Synopsis: Students explore the basis of the observed magic trick and consider how the shapes of product containers influence customer perceptions of how much product they contain. In **What's Going On Here?** , students explore the relationship of container shape to volume. They are introduced to the concept of design constraints and are challenged to design an eye-fooling perfume bottle.

Related National Science Education Standards:

Content Standard B (Physical Science):

As a result of their activities in grades 5-8, all students should develop an understanding of **Properties and Changes in Properties of Matter.**

Fundamental concepts and principles that underlie this standard include:

A substance has characteristic properties…

Content Standard E (Science and Technology):

As a result of activities in grades 5-8, all students should develop **Abilities of Technological Design**, including the ability to **Design a Solution or Product**, and **Understandings About Science and Technology**.

Fundamental concepts and principles that underlie this standard include:

Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, … other constraints limit choices in the design, for example, … aesthetics.

Related Benchmarks from Benchmarks for Science Literacy:

Section IB (Scientific Inquiry):

By the end of 8th grade, students should know that:

What people expect to observe affects what they actually do observe.

Section 3A (Technology and Science):

By the end of 8th grade, students should know that:

Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems, but they usually have to take human values and limitations into account as well.

Section 3B (Design and Systems):

By the end of 8th grade, students should know that:

Design usually involves taking constraints into account. Some constraints are unavoidable … Other constraints … limit choices.

Section 9C (Shapes):

"Exploration of how linear measures, areas, and volumes change with size will strengthen the concepts themselves and help, generally, in leading students toward ideas of scale… (Most children in grades 6-8 expect area and volume to change in direct proportion to linear length.)"

Glossary:

- **design constraints** Circumstances which limit or restrict the choices a designer has in design of a product. Some constraints are unavoidable and others relate to such considerations as economics, aesthetics, or marketing.

Important Science Concepts:

1. Containers of different shapes may have the same volume.
2. Liquids assume the shape of their container.

TRICK #4: The Magic Milk Pitcher Teacher's Guide (continued)

Materials for Inquiry:

- Water
- Food Coloring
- Measuring Cups or Graduated Cylinders
- 2 Plastic Cups, one smaller and a little shorter than the other (One should fit into the other with a space between the walls.)

Procedure:

Engagement: Show the video of the **Magic Milk Pitcher Trick.** Have students brainstorm in their **Inquiry Journals** possible explanations for the trick.

Exploration, Explanation, and Extension: see **Student Handout**

Evaluation:

1. Have students propose an explanation for how toy "baby bottles", which appear to empty as they are tipped and refill when turned upright, are constructed.

Ideas for Further Exploration:

Students might consider one or more of the following questions:

1. Does the use of milk rather than water make the trick more visually effective?

2. How do the shapes of cardboard containers affect perceptions of the volume of product in the container?

3. What effect do illustrations on cardboard packaging have on consumer perceptions?

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Student Handout

Materials for Each Inquiry Team:

- Water
- Food Coloring
- Measuring Cups or Graduated Cylinders
- 2 Plastic Cups, one smaller and a little shorter than the other (One should fit into the other with a space between the walls.)

Exploration:

1. Fill the larger container about 1/3 full with colored water.
2. Set the smaller container into the larger one, pushing it down to the bottom.
3. Describe the change in the liquid level in the larger container.
4. Using 2 containers, fill the outer one so that it is nearly up to the top of the inner one.
5. As you tip the outer container as though to pour the water out, tip the inner container forward so that it touches the outer one and the water flows into the inner container.

Explanation:

Based on your observations, revise your explanation for how the trick was done if needed. Then view the video segment in which the Magician shows details of the trick. Describe how the design of the pitcher helped to create the impression that milk was actually poured into the cone.

Extension:

The eye-fooling appearance of the milk pitcher misled us into thinking the pitcher contained much more milk than it actually did. How easily fooled are we when it comes to guessing the volume of a container? See **What's Going On Here?** to find out.

TRICK #4: What's Going On Here?

Student Handout

Product Design and Design Constraints

In this trick, a trick pitcher was substituted for an ordinary pitcher. Would the trick have been as effective with an audience that had never seen a pitcher of milk before? What if he had used a cardboard quart milk carton? Would you have believed it really had milk in it? Magicians use seemingly familiar objects to create their illusions. How was he able to fool us? At the beginning of the trick, the pitcher appeared to be full. When the magician poured milk into the paper cone, the level of milk in the pitcher fell, just as we expected.

Putting a slightly smaller container inside the pitcher as a liner was important in two ways. Can you explain how? First, with the liner in place, the magician counted on the assumption that our experiences with liquids would fool us into believing that there was much more liquid in the pitcher than was actually the case. Second, the liner allowed some of the liquid to flow into the liner so we would believe that milk had actually been poured into the empty cone.

It turns out that people commonly find it hard to judge how much liquid is in a container, unless it is one they have had a lot of experience with, such as a 2-liter bottle. For example, people tend to think there is more liquid in a tall slender container than in a short fat container of the same volume! Product designers sometimes take advantage of our tendency to be misled about the volume of a container when designing the shape of product containers, such as cereal boxes and perfume bottles.

Exploring How Volume Changes with the Size of a Container

Materials for Each Inquiry Team:

- Empty Bottles and Jars of a variety of sizes and shapes
- Measuring cups or Graduated cylinders

TRICK #4: What's Going On Here? Student Handout (continued)

Procedure:

1. Collect a variety of empty bottles and jars, such as shampoo bottles, pickle jars, perfume bottles, and salad dressing bottles.

2. Fill the bottles and jars with colored water and have another team predict which has the most liquid, the next most, etc.

3. Measure how much water each contains and see how accurate their predictions were.

4. Compare results with other teams.

Math Connection:

Measure the dimensions of the containers. Compare the predicted and actual volumes of containers with similar heights, base widths, or base lengths. If you double the height, base width, and base length of a rectangular container, how much do you increase its volume?

Questions for Discussion:

1. Are there certain container shapes that tend to exaggerate the apparent volume of the contents?

2. If you were a container designer, what other considerations would influence your design, other than the customer's impression of how much liquid he/she was purchasing?

3. Is it fair for package designers to mislead customers about how much product they are getting?

Engineering Challenge:

Design an eye-fooling container for perfume. Sketch your design. (If you model your design after an existing one, be prepared to explain your choice.)

Observe the change in level in the pitcher before and after the milk is poured into the glass. Is it what you expect, considering the amount of milk in the glass? Do you notice any difference between the way the magician handles the pitcher when he pours the milk into the paper cone and when he pours it into the cup?

