Which Paper Towel Is *Best?*

A common classroom investigation is tweaked for student-directed inquiry

By Jann Joseph

Habits of inquiry should be nurtured as early as possible. Elementary students must be challenged to ask good questions and develop inquiring attitudes that prepare them for middle and high school. How does a teacher determine what is a good question to promote inquiry? As a science teacher, educator, professional developer, and science program reviewer, I have often observed that the default is to use "good" science investigations from textbooks or the internet. Unfortunately, those good investigations often ask questions that are actually quite closed and safe. As an alternative, I tested an investigative question that helps upper elementary (grades 5–6) students and teachers develop a deeper understanding of science as inquiry. The question I pose is: "Which paper towel is best?" This well-known investigation is given new life with emphasis on developing valuable questions and student-directed inquiry.

The term *best* opens the discussion because it is deliberately subjective. Merriam-Webster defines *best* as offering or producing the greatest advantage, utility, or satisfaction. With this definition in mind, our role as teachers is to help students decide what is to their greatest advantage. Is it utility or satisfaction? The terms *utility* and *satisfaction* allow for deeper questions to emerge. What does *utility* mean? Would students prefer to test utility or satisfaction? Or would utility provide satisfaction in the case of paper towels? If we consider utility, then what is best—Strength? Absorbency? Texture? Biodegradability? We should expect that students' experimental designs will differ based

on preference or what they consider "best" attributes. In my classes, students have tested absorbency, strength, color and texture, and content of recycled paper.

Revising the Structure

"The best paper towel" lesson is designed to address inquiry as outlined by the National Science Education Standards (NRC 1996). Most teachers review or teach a scientific method to their students, and I have seen numerous classrooms in which students make careful observations and record those observations. Also common is discussing and writing predictions or hypotheses, plus many students regularly draw conclusions and make inferences from their experiments. What is not addressed carefully and "like a scientist" is the design of the investigation. In many classrooms students are given a worksheet that includes Purpose, Background Information, Observation, Prediction, Procedure, and Conclusions. Although these all make up the steps of a scientific method, how we address Procedure is what makes the difference. Unfortunately, in most cases the procedure is prescribed and includes a series of steps that students need to follow.

In the "typical" inquiry lesson the teacher provides the steps or procedure for the investigation. Students follow directions and then fill out a worksheet. In this scenario the students are collecting data but within the limitation of structured inquiry. They are exploring a question presented by the teacher—in this case absorbency of paper towels—are given the procedure, and are making conclusions based on their findings. In guided inquiry the teacher provides the question and equipment and the students design the procedure, analyze data, and make conclusions. In student-directed inquiry the teacher presents a general topic and allows students to develop their own questions and design their own experiments. In open inquiry students select the topic and investigate their own questions.

Student-Directed Inquiry Lesson

The deliberate ambiguity of determining "best" allows students to develop their own questions and predictions or hypotheses based on their prior experiences and observations. Asking the students to test which is best takes them further and allows for ownership of the experiment as they determine what they wish to test and what data they can collect. In this scenario students are directly involved in developing the experimental procedure and determining the variables in their experiment. They also make decisions about the factors they will control and how they will replicate the experiment so that they can obtain evidence to support their hypotheses.

First, gather as many varieties of paper towels as possible including name brands, store brands, and those currently used in your building. Other materials you'll need include: scissors, stopwatches or clocks, rulers, beakers, droppers, measuring cylinders, weights (pennies work for determining strength), magnifying glasses, scales/balances, water, waterproof plates, cafeteria trays, and bowls. Include other things only you can think of! Each group will not use all the materials. The goal is to provide variety and choice.

Engage

Show the various towels and ask students "Which paper towel do you think is best?" Ask them to explain their responses. Talk about which ones they use at home and at school. How are they different? Have they seen TV ads for paper towels? Which is their parents' favorite? Do they know why? Are all paper towels made for the same purpose?

Explore

Break students into groups. Walk among them and help them determine what they want to test to determine "best." Before students can collect materials and start their investigation, they must provide a minimum of the following:

- What is their investigable question?
- List of materials they need.
- What they plan to measure and how.

Allow students to conduct their investigation and record their data. At this point their notebooks should be checked for their hypotheses or predictions and the data they collected. For most classrooms this exploration will take about 30 minutes. If the classroom can be managed for a longer period or if volunteers are available, teachers can continue the lesson on the same day, but for most, this is a good time to stop.

Explain

The next step is for students to report on what they did for their experiment and what evidence they have to support their choice for the best paper towel. Note that so far in the lesson I have not mentioned replication and control variables. Many teachers tell students that they need to replicate and how many times. My experience is that the greatest effect occurs when students recognize for themselves that they only collected a limited amount of data and that it is not enough to say that what they observed is not because of chance. Ask students to explain how they can make their conclusions with some certainty. How many times do they believe they should repeat the experiment? They should be encouraged to explain their choice. If necessary, use a die or coin to demonstrate chance.

Evaluate

Students go back into assigned groups to review and refine their experiment. The teacher can evaluate students' notebooks as he or she moves around the classroom.

Some things to consider—Is the hypothesis further refined? How many replications do they plan? Are they now including control variables in their experiment? For example—What things are students holding constant for all paper towels? Did they make accommodations for one- or two-ply paper? Are they using the same size? Is the same student responsible for adding drops of water so it is consistent?

Extend

Students are allowed to do the experiment again and report their findings to the class. Are there other questions they would like to ask? What do they do differently?

Some students will be interested in the social construct of "best." They can be encouraged to do a survey of their peers and be taught how to gather social science data. Students can be facilitated as they develop a short survey in which participants are asked to rank the towels on texture, color, or another subjective element. This is an excellent extension activity and can provide opportunities for students to discuss the merits of their scientific findings and how it compares to their social science research. For the upper elementary teachers this extension is an opportunity to combine science, math, and social studies standards in a unit or as part of a collaborative unit with a team of teachers.

Infinite Inquiry

It is not uncommon for some groups to be overwhelmed as they try to make a decision about what to test to determine best. But they should use their dilemma to help them understand the nature and complexity of developing a good scientific experiment. If your students need additional help, here are some things my students have done in the past to test absorbency:

- Roll a measured piece of towel and dip into a measuring cylinder with a specific amount of water for five seconds. Remove quickly and read off the amount of water left in the cylinder.
- Pour a measured amount of water, for example, one milliliter or 10 drops on a waterproof surface, add the paper towel, and measure the diameter of the spread of the water after 30 seconds.

To test strength, students tried the following:

- Two students hold the paper above a large container and one student gradually adds weights until it breaks. Record the time.
- Two students hold a wet paper towel above a tray and one student adds pennies until the towel breaks. They will have to determine wetness using a specific amount of water for each towel as described above.

I have found that inquiry is difficult to do in one lesson. At least three successive lessons are optimal. The first day/period focuses on planning, the second on executing the plan, and the third on reviewing and assessing what worked and in most cases, redoing or developing a plan to improve the experiment. The follow-up is crucial because teachers routinely ask students what they would do differently the next time, but it is not often that students actually revise and redo the experiment. Doing this will allow them to better understand science inquiry as ongoing, rather than a series of steps with a finite conclusion.

Asking students to design an experiment to determine which paper towel is best at first glance may seem unfair and ambiguous. It asks our students to consider a concept that is qualitative or subjective and develop an experiment that is testable and repeatable. But it challenges us and them to carefully think about what best means. It develops critical-thinking skills as they grapple with the social constructs of quality and soon recognize that what *best* is for one may not be for another. ■

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Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades 5–8

Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Teaching Standards

Standard A:

Teachers of science plan an inquiry-based science program for their students.

Standard B:

Teachers of science guide and facilitate learning.

Standard E:

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to learning science.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.