

# The Toughest Towel

Days 11,12



## OVERVIEW

This 2-day experiment introduces students to the difficulties of designing a good experiment. The paper towel experiment demonstrates the importance of controlling for unwanted effects. In the first step, students brainstorm techniques for measuring paper towel strength (wet versus dry, tearing versus holding weight). After agreeing on a technique that produces quantitative observations, students design an experiment to measure the amount of weight that a wet paper towel can hold. Students write their own methodology, conduct the experiment, and evaluate the strengths and weaknesses of their methods. Students consider the issues in combining data from different groups. On the second day, students design new experiments to answer some of the questions that arise from the first day.

**Focus Question:** *What must scientists think about when designing an experiment?*

## SCIENCE SKILLS

- ✓ Students will be able to write detailed methods for an experiment.
- ✓ Students will be able to explain how different methods affect data interpretation.
- ✓ Students will be able to draw conclusions from data.

## BACKGROUND

Background information describing the concepts in this lesson is presented in the following sections:

Section I: Research Q&H – *Qualitative and Quantitative Observations*

Section II: Experimental Design – *The Paper Towel Experiment*

Section II: Experimental Design – *Controlling for Unwanted Effects*

Section II: Experimental Design – *Repeatable*

Section II: Experimental Design – *Replication*

## MATERIALS

- ✓ overhead transparency of diagram at end of lesson plan
- ✓ 1 ring stands per student group
- ✓ 3-4 binder clips per group
- ✓ water, cups, and spoons
- ✓ paper towels - 3-5 different brands. The results are much easier to keep track of if brands have dramatically different color patterns.
- ✓ standardized weights - for example, large heavy washers. All weights should be the same and should have no sharp edges. You will need enough weights so that each group can have enough to break through a wet paper towel. (This may need to be tested beforehand).
- ✓ 1 large box or shallow plastic bucket per group (optional)
- ✓ student worksheet (attached)

## DEVELOPMENT OF LESSON



1) Students meet as a class and brainstorm different methods for testing paper towel strength. Students should debate which methods would lend themselves to quantitative observations. Show the weights and the ringstands to the class, stating that this is the available equipment. Ask the students how the equipment could be used to make quantitative observations. The diagram at the end of the lesson can be copied onto an overhead transparency to show the students.



2) Introduce the idea of controlling for unwanted effects. Ask the students for some examples of things that might need to be controlled in different experiments. For example, what would you need to control for in a study comparing insect growth between two species? *Available food, temperature, water.* What would you need to control for in a study comparing moss growth on deciduous versus coniferous trees? *Rain or moisture, location of trees, age of trees.*

3) Discuss the factors students need to control for in the paper towel study. How wet will the towel be (# of teaspoons of water applied)? Will they drop or place the weights? How many clips will they use? Will it matter if all the groups have the exact same methods?

4) Break the students into small groups (3-4 students per group) and have them write up a group methodology on the attached worksheet. They should specify exactly how they will conduct the experiment and what they will control for.

5) Pass out the equipment and let the students begin. Paper towels of several different brands should be at the front of the room. (Make sure that paper towels are labeled even when the wrapper is removed. You could write the brand name inside each tube and/or post and label one demonstration towel of each brand.) This is a very loud experiment. As paper towels break, the weights fall to the desk or to the floor. It may be easier for the students to work directly on the floor. The box or plastic bucket can be placed under the ring stand so that the weights don't fall all over when the towel breaks.

6) Students should record results as they go. They should finish one replicate for each paper towel brand on the first day.



7) On day 2, have the students meet as a class and discuss what happened on the first day. First, of course, you will discuss which brand of paper towel is strongest. Tell the students that you want to combine the data from all the groups to make a decision about which brand is best; students can record their data on a class graph at the front of the room. Ask students why there is so much variability in the results. Students will probably be frustrated that other groups didn't do the experiment the same way and so they can't compare results easily. They will probably find



that the amount of water used and the method for stacking the weights makes a big difference in the results. Ask the students for suggestions to improve the class data. Introduce the concept of repeatability. Data can only be compared if they are collected in the exact same way.

- 8) Tell the students that they will have today to answer some of the unanswered questions. Let the students break into their small groups and choose a research question. You may want to go over the suggestions below as a group or you may want to let the students think up their own questions if they can. All the groups do not have to study the same thing or the class could decide to redo the entire experiment using a standardized amount of water and weight-stacking method. There are lots of other things to test. The following is a brief list of ideas:
- ✓ If you measure the same brand 3 or 4 times, will you always get the same results? In other words, is there a lot of variability between towels of the same brand? Would you care about this when purchasing a brand of towel? Is there more variability for some brands than other brands?
  - ✓ How much difference does the stacking method really make? Try the experiment a few times, controlling for everything but the stacking method (one brand, a standard number of clips, and a standard amount of water but add the weights as a stack or as a pile). Students will need at least two replicates for each stacking method.
  - ✓ How much difference does the amount of water make? Try the experiment again, controlling for everything but the amount of water. Students could do 2 or 3 replicates of wet and dry or you could try 1, 2, 3, 4, 5, teaspoons of water. How much difference does the number of clips make?
  - ✓ How do the school bathroom towels stack up?
  - ✓ Does it affect the strength if there are pinholes in the towel? Small rips?
  - ✓ What if you drop the weights from a fixed height?
- 9) Have each group write up detailed methods on their worksheet.
- 10) After the teacher has checked the methods to make sure that all the details are specified and that there will be some replication, students can carry out their experiments.
- 11) Meet again as a class and have students share the results of their experiments. Discuss what you learned as a class about the effects of stacking methods, wetness, pinholes, or variability. Ask students whether they think that the experimental design really mattered. What were the most important things to control for?

## **DISCUSSION QUESTIONS**

- 1) When you wrote your methods, were you able to think of every last important detail? Do you think scientists usually forget things? What do they do when they forget something?



- 2) What is the effect of variability on research results? If the paper towels were exactly the same and you did exactly the same thing each time, would you get exactly the same results? Why or why not?
- 3) Was replication necessary? Why or why not?
- 4) What is the effect of controlling for things like water and stacking methodology?
- 5) What did you learn from observing the effects of different methods on the results?
- 6) If you wanted to measure paper towel strength differently, how would you have to change the experiment?
- 7) Do you think advertising biased your results? How might it have had an effect?