RECOGNIZING THE DILEMMA OF STRUCTURED LABS
Using Paper Strips to Teach the Value of Unexpected Results

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In any introduction to science, a mandated lecture on scientific method occurs early in the course. There are diligent students who memorize the steps, delve into the differentiation of inductive and deductive reasoning, and can, when requested, model the method for a specified problem. When these same students get to the actual laboratory "experiments," they see little resemblance between the process of completing their assignment and the scientific method. They find that the end results are only achieved by following the instructor's steps to the letter. When methods fail, students feel a real sense of disappointment and anxiety about unexpected results. Students tend to conclude that nothing is worse than not duplicating the desired results.

Is this the attitude about results that we want to develop in our students? While it is true that structured experiments allow the instructor to focus investigations and develop methods, the emphasis must remain on science. We need to address the dilemma of structured experiments early. Students must learn to be careful when repeating an experiment, but they must be open to the unexpected. They need to understand the opportunity that "wrong" results present. How can we lighten up student reaction to unexpected results? Why not head off this situation during that early scientific method lecture?

The simple exercise that follows is one I have used with fourth graders, seventh graders, freshmen, non-biology majors, and even "honor students" in college. In all instances the attention and the "aha" were optimal during a lecture that some consider rather predictable.

**Materials for a class of 15:**

5 rolls of scotch tape
5 pairs of scissors (small is better)
20 paper strips lined on one side only
(1 inch wide by 8 inches long)

**Figure 1.**

![Paper Strip](image)

**Method:** Xerox one side of lined paper. Cut strips so that a middle line is showing. See Figure 1.

**Initial Procedure:**

Pass out supplies and 1 paper strip to each group of three students. Have each group tape the ends of the paper strip to form a circle.
Begin by pointing out that due to their experience with these materials they are in an excellent position to move from past observation directly to hypothesis for the following problem:

"What happens when I cut a paper strip circle in two?"

Ask the students to predict results. Gather their responses. Write this or a similar specific hypothesis on the board:

If I tape the ends of the paper strip to form an 8 inch circle and then cut the width of the paper strip in half, I will end up with two circles 8 inches in circumference and 1/2" wide.

Tell the students that we will now test our hypothesis. Student A in each group will cut the circles. (Hint: Pinch the end of the circle to start the cut.) Groups will write down their results and then compare them with other groups.

Figure 2.

Now lead a discussion of the acceptance of the hypothesis. Which groups accept or which groups reject?

Pass out another paper strip to each group. Tell the students that you want them to repeat the process. (Look out for groans.)

Student B will cut this time. Step in just before they tape their papers and tell them to give a half twist to one end of the strip so that the blank side matches up with the lined side. See Figure 3. If anyone complains, point out that the procedure is allowed in terms of the hypothesis.

Figure 3.

Have the students cut carefully. See Figure 4. (Wait for the "aha.")

Figure 4.

Repeat the procedure of writing down results and discussion. What does this do to their hypothesis? What can they do to control this?

Suggest that they alter the original hypothesis by adding the phrase "lined side to lined side" after the word "circle." Write this on the board.

Before they get too far in their discussion, quickly pass out the third strip of paper. Ask them to twist one end one full turn (360 degrees) so that lined side matches lined side. See Figure 5. Tape carefully.

Figure 5.

Ask them to predict what will happen. Is anyone sure? Is this procedure allowed according to their hypothesis? Student C will now cut.
What does this do to the process of accepting the hypothesis? (Groups should still accept the hypothesis.)

Ask the students if there are suggestions to "improve" the hypothesis. Most students will feel that the procedure should be outlined more specifically.

They will recognize that individual interpretation led to variability.

If they desire a specific result, they need to develop specific methods. Many of the lab experiments they will complete in the course are the result of similar testing.

But what else happened? They got excited about the "wrong" results. They found the unpredicted results intriguing. If you don't believe me, try this: Pass out the fourth strip. Most groups will immediately try the one and 1/2 twist before you say a thing. (And I'm not showing you this one--you'll need to find out what happens on your own!)

This exercise stimulates students, even those who don't normally respond. They see the need to reevaluate methods. In order to do this they need to experience unexpected results. They value their "wrong" result because it surprised them.

Results that generate curiosity invariably lead to more science.

This truth is overlooked but remains a necessary part of any scientific method discussion. Students need to know the value of "wrong" results, even if the instructor does not.