✦✦ Chapter 25

Critical Thinking in Elementary Science

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Abstract

This paper, the fourth in the Teaching K–8 *remodelling series, briefly explains the need for students to learn how to think scientifically, and why standard instruction fails to achieve this goal. It then provides a remodelled physics lesson.*

The process of remodelling lesson plans to encourage critical thinking has previously been canvassed in this journal in three previous editions. The first covered a general introduction to lesson plan remodelling, the second illustrated the process of remodelling social studies lessons, and the third, the process of remodelling language arts lessons. Today you will be given a sense of how to infuse critical thinking into science lessons. Whenever we remodel a lesson we redesign it in the light of our desire to improve it by infusing more critical thinking into it.

A critical approach to teaching science is concerned less with students accumulating undigested facts than with students learning to think scientifically. As students learn to think scientifically, they inevitably do organize and internalize facts. But they learn them deeply, tied into ideas they have thought through, and hence do not have to re-learn them again and again. Education in science should combat the common assumption that "Only scientists can understand science." Scientific thinking should be a routine dimension of everyone's daily life. But students have to do something as close to real scientific thinking as possible.

Scientists are not given experiments; they begin with a problem or question, and have to figure out how to solve it through trial and error and experiment. They struggle with problems, explore blind alleys, and often do not have step-by-step routines to fall back on. Typical science texts, however, present the student with the finished products of science. These texts present information, and tell students how to conduct experiments. Thus, students rarely engage in or see themselves as able to engage in scientific reasoning. Texts also require students to practice the skills of measuring, graphing, and counting, often for no reason other than practice. Sometimes, the experiment or study has no obvious relation to the question it is presumably designed to settle. The reasons for the design of experiments and forms of presentation of data are rarely made clear. We need to teach science in a way that avoids these pitfalls.

Below we provide an example of a lesson remodelled to overcome some of these problems.

Ah Chute

Objectives of the remodelled lesson
The students will:
- design and test parachutes
- discuss characteristics which affect the descent rates of parachutes
- transfer insights about parachutes to other falling objects
- hypothesize, test, and refine their hypotheses regarding the descent rates of objects

Original Lesson Plan

Abstract

This lesson focuses on the key question, *"What is the rate of descent of your parachute?"* Students design, build, and test parachutes (twice each from three different heights), calculating the rates of descent in meters per second. They then discuss the following questions: *What things affect the rate of descent? Did the rate of your chute change from one height to another? Why? Select the five slowest rates of descent and the five fastest from the class chart. Have those students display and describe their parachutes. Were there similarities? What can you conclude? How would you modify your parachute to improve its performance?*

from *The Sky's the Limit* Arthur Wiebe and Larry Ecklund editors. Fresno Pacific College. Project Aims. © 1982 p. 13

Critique

A major weakness of this lesson is its failure to connect how a parachute works to the topic of falling objects in general. It misses the opportunity to teach important science concepts such as gravity, wind resistance, and inertia. This trivializes the lesson by restricting it to one narrow topic.

This lesson offers the opportunity to have students engage in extended scientific reasoning — posing questions, testing answers, posing new questions, conducting further tests, while assessing their original ideas and refining their initial generalizations. Such extended work better reflects science than a one-shot experiment. Furthermore, headway can be made on the broadened topic without elaborate preparation or difficult measurements.

Strategies used to remodel
S-10 clarifying ideas
S-15 generating or assessing solutions
S-1 exercising independent thought
S-7 transferring ideas to new contexts
S-31 refining generalizations

Remodelled Lesson Plan

Begin by asking if anyone knows what a parachute is and what it is for. Students should know that a parachute is designed to keep something from falling too quickly, that is, that it slows the rate of descent. Rather than using the key question in the text, focus attention on the discussion question of what affects rate of descent. Ask students what characteristics make a good parachute, and how they know. ***S-10*** Ask them to think of situations which call for using a parachute. ***S-15*** Ask if there are any other possible solutions for these problems. Have them consider questions like these, "What affects the rate of descent of a parachute? How could we find out? How does a parachute work? Why does it work?"

Students could then design their tests, as well as their parachutes. ***S-1*** Perhaps they could try to make appropriate parachutes for various specific purposes or objects. Students may repeat their tests on different days and/or in different places (e.g., windy versus protected areas) and compare results. As in the original, have them compare slow with fast parachutes, and speculate on which differences affected the descent rate. They could compare parachutes of different materials, and carrying different weights and shapes. Ask them, "What does this tell us? About air? Gravity? Objects? Why did we get the results we did? Why does the parachute fall slowly?" Students could then begin making generalizations and hypotheses, and designing experiments to test them.

You could then broaden the original question to, "What affects the rate of fall of objects, and why?" ***S-7*** Students could practice making and refining generalizations. ***S-31*** Suggest that they experiment with other kinds of falling objects, i.e., paper planes, feathers, books, rocks, pillows, etc. Students need not measure, they could simply group objects in general categories of fast-falling, slow-falling, and in-between speeds.

After each test or each few tests, discuss results. "What were you testing for? (To see if weight, size, density, etc. affect fall rate.) What did you do? (Dropped this and that from the same height at the same time and place.) Why? (If what we tested for affects fall rate, since they're the same in every way but this, then this should have fallen much more slowly than that.) What happened? (This fell much more slowly that that.) What does that mean? Could there be another explanation? Were there other differences between the two objects that could have accounted for the results? How do these latest findings compare with our earlier tests? What other questions could be asked? Is there anything else that you noticed, that would explain the results? What else could you test for? Now what would you say affects descent rates? Why? What *doesn't* affect descent rates? Why?"

The class could keep notes on the discussions, listing ideas, tests, and conclusions. The teacher could, perhaps during the summary, point out tests that failed or hypotheses which were proven wrong, but from which students learned something. Students could use the class records, sort slow, medium, and fast falling objects, and write short passages comparing the three kinds of objects, or write about other factors or conditions which affect descent rate, trying to generalize from them, and speculating on the reasons for or principles behind the results.

The material in this lesson could be related to botany with a discussion of different shaped seeds and seed containers, and how well they scatter seeds. Students could discuss objects falling on the moon. If necessary, first point out to students that the moon has less gravity and less air. Students could compare how different objects would fall on the moon as opposed to Earth. ***S-7***