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Thinking and Working Like a Scientist

It is not unusual for students to take courses in which they learn about the products of scientific endeavors. At the University of Rhode Island, Honors students have had the opportunity to see how scientists actually work.

"Thinking and Working Like a Scientist" was first offered as a special laboratory in a freshman zoology course, then expanded into a stand-alone Honors offering. It draws primarily science students, but there have been a scattering of business and humanities students as well.

The catalog description of the course advises students that they should not enroll unless they feel comfortable working by themselves in ambiguous circumstances; in this way only students who will thrive in the decidedly free-form environment of the course bother to sign up.

Each week of the course focuses on a personal attribute necessary for a scientist, and there is an exercise that will allow the students to demonstrate that attribute. Thus, we have an Initiative Week, Patience Week, Persistence Week, Logic Week, Creativity Week, Resistance to Rejection Week, Verbal Communications Week, Information Week, Written Communication Week, field trips to working scientific labs, and a Day with the Pros—in which the students work side-by-side with someone who makes his or her living as an applied scientist.

The core of the course is the Thought Log. The instant the students receive an assignment, which they usually draw by lot, because luck is an important component in science, they are expected to jot down in the Log what their first thoughts were about how they would solve the problem of an assignment. If that approach doesn't work, or if they reject it before even starting on that line of direction, they are supposed to enter that information also in the Log. After the assignment is completed by all the students, we discuss the Logs to see what the thought process was that led to the speediest solution.

The semester starts off in dramatic fashion with the Initiative Week. Scientists, especially newly minted ones, have to be scroungers and be willing to ask favors of people—to borrow equipment, share data, compare techniques, etc. In the first week, then, each student receives a scavenger hunt type of assignment. Examples include, "Bring me exactly 100.00 grams of camel dung, dry weight." Here the student has to somehow persuade the zoo to give him the material; then he has to find an oven and a balance. "Here is a length of yarn. It is very unusual. As a matter of fact, it can be found in only one place in the state of Rhode Island. Bring me another piece." It took one student 16 hours; starting with the University's textiles department, she identified the yarn, but then she had to figure out that if it could be found in only one place in Rhode Island, it had to be some kind of industrial yarn, rather than a home knitting yarn.

Other initiative assignments include bringing in exactly 10 human white blood cells, without any red blood cells, filling a vial with hydrogen sulfide, and obtaining the signature of the governor of Rhode Island.

Much of science involves repetitive work, a characteristic which does not appear on Jacques Cousteau or Carl Sagan programs. For the Patience lab, students are given a one-pound box of birdseed which contains three types of seeds. The assignment is to tell me, with an accuracy of five significant figures, what fraction of the whole is millet, canary, and oat seeds. To satisfy the requirement, the students have to somehow separate and then count all 74,000 seeds in the box. This assignment is fascinating, because the students immediately sort themselves out. Some phlegmatically get a camel's hair brush, sit down, and have at it, emerging 20 hours later with the answer. Others say to themselves "no way," and spend hours trying to devise some kind of mechanical separator, using sieves, fans, water, etc. In the postmortem of the exercise, the students say they hated it all the time, but found that it was the most revealing of all the exercises during the semester.

The Resistance to Rejection assignment is not labeled as such. Scientists are always having to submit manuscripts and grant proposals, and experiencing rejections, from which they must recover and try again. The students here are given a small library research paper which they are to submit to me. I return it to them with the comment, "This is no good. Try it again, but with more detail." When they resubmit, I say, "Better, but it's too cluttered. Simplify it. Do it again." Most of the time, their reactions are unprintable. After the third submission, I show them collections of NSF, NIH, and journal referee commentaries, all of which are contradictory. We then discuss strategies for keeping one's sanity in these conditions.

The Oral Communication week is the most traumatic. Acting as a committee of the whole, the class has to *give* a freshman biology lecture—to 300 fellow students. Each Honors student has to speak for about seven minutes. Afterwards, we discuss scientific communication, professional meetings, speaking under stressful conditions, and public speaking techniques.

During Day with the Pros week, pairs of students spend a day with a surgeon, a vet, and a pathologist. The task is to see how much science these people use in their daily professional activity, considering that almost the whole of each pro's training was in science. The students are amazed at the small amount of science they see compared to business, psychology, and running around. To balance this, we spend some time on a research trip conducted by the local aquarium.

At the end of the semester, we review some of the great scientific discoveries which have been documented in human terms, such as the discovery of the DNA double helix by Watson and Crick. By the time the course is over, science has been thoroughly demythologized, but it has been humanized; and the students have a fairly good picture of what a scientist actually does with his or her time.

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A Lake Study in the Classroom

After teaching field-type ecology courses for almost 30 years, I was asked to develop a two-semester, nonscience major, freshman biology course. Since I couldn't think of a more important group of students with which to work, I accepted the task with enthusiasm. I soon realized that the hands-on type of lab approach I had been using for so long would present a challenge in the confines of four walls, with only electrical and water outlets connecting me with the outside world.

I decided to bring that world inside. First, I bought an eight-section wallpaper mural and placed a mid-south hardwood forest on one wall of the lab and posted outdoor scenes on the other three walls. At least we had something to look at and talk about. Next, I decided that we needed a real lake in the lab, so I went to a local park and took slide photos from the top of the watershed down to the very edge of the lake. I then borrowed a fresh water ecology exercise from the U. S. Forest Service (*Investigating Your Environment Series*, 1976) and modified it to fit my students' needs.

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I begin the lab with a succession of slides of the lake, as if we were walking down the hill to the water. We discuss signs of beaver activity and weather conditions; we ask—"Is the lake a natural or a man-made community?"; we look for evidence of possible fishing activity and what that implies; and so on. The students take notes as though we were on an actual hike. Then students turn their attention to an aquarium stocked with the necessary flora and fauna to complete the study. With the necessary tables provided, the students can estimate the dissolved oxygen and pH of the water. Once the students have made their observations and recorded their predictions, they check their work with a relatively inexpensive Hach Water Test Kit.

I find that the students and teaching assistants enjoy the experience, and we all get to spend a couple of hours "out of doors" as well. This simple activity could be expanded or modified to investigate soils, sand dunes, forests, deserts, or any other habitat. The emphasis is on the scientific method of observing, recording, hypothesizing, and testing.

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