The Curiosity Shop (Or, How I Stopped Worrying About Delta Shapes and Started Teaching)

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The Curiosity Shop
(Or, How I Stopped Worrying About Delta Shapes and Started Teaching)

SUSAN TOMLINSON
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There is a program on the Food Network called “Cooking Live.” I happen to be a regular watcher of this very informative show, which is hosted by a personable and knowledgeable chef named Sara Moulton. What sets this particular cooking show apart from the others is that it is less about entertainment than it is about actually teaching the viewer how to make proper pancakes, or how to chop an onion, or how long chicken can marinate safely at room temperature. (I think I remember Sara saying one half-hour, tops, though the FDA says never.) It is a wonderful mix of process and content.

It is also partly interactive. Viewers may call with questions or input while the show is being aired. This they do in legions. I actually tried it once myself. Sara asked for suggestions for a recipe for sopapillas, a southwestern specialty that I happen to know. For half an hour I dialed and redialed, only to be met with the busy signal of all the other chef wannabes calling with their sopapilla recipes. When someone else was tapped for the simple recipe,1 I was somewhat relieved; I was really only calling out of a sense of duty—if I know the

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1 Sopapillas
4 cups sifted all purpose flour
1 ½ teaspoons salt
1 teaspoon baking powder
1 tablespoon lard or butter
1 package active dry yeast
¼ cup warm water (105° to 115° F.)
1 ¼ cup scalded milk, approximately
1 quart lard or cooking oil
answer to a question, I feel compelled to share the information. My husband says this makes me a know-it-all. I prefer to think of myself as a teacher.

If I had been chosen by the Food Network’s telephone gatekeepers, I would have probably started my conversation with Sara the same way everybody else does, by saying, “First of all, I just love your show.”

Everybody says it—everybody—without fail. I’ve even started listening (possibly from a sense of know-it-allness) for someone to ask Sara a question just once without the requisite preface: “First of all, I love your show.” They always say these words or some variation thereof. And they mean it, too.

I commented on this phenomenon once to my husband, who also happens to be a teacher (though he claims not to be a know-it-all). Wouldn’t it be fabulous if our students started every question they asked of us by saying, “First of all, I love this class?”

Of course, this never happens. People may say it with giddy abandon to Sara Moulton about a cooking show, but how many of us pontificating about geology, or chemistry, or physics—which, unlike sopapillas, good as they are, are Really Important Stuff—have such a lovely thing happen every single day for every single question? None, that’s how many. Now why do you think that is? In both instances, a lecture is occurring. Content is delivered. People are probably taking notes. There will be assessment (either your sopapilla works, or it doesn’t). And style-wise, Sara Moulton doesn’t do anything more entertaining than most of us probably do in the classroom. In fact, I dare

1 Combine dry ingredients and cut in 1 tablespoon lard.
2 Dissolve yeast in water. Add yeast to scalded milk, cooled to room temperature.
3 Make a well in center of dry ingredients. Gradually add liquid to dry ingredients, working into dough until it becomes firm.
4 Knead dough 15 to 20 times; set aside for 10 minutes.
5 Heat 1 quart of lard to 450° F. in a deep fryer.
6 Roll dough to ¼ inch thickness, then cut into triangles. Fry the sopapillas a few at a time in the fat, holding them down until they puff up and become hollow.
7 Drain on paper towels; dust immediately with a sugar-cinnamon mixture.
8 Serve with honey.


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say I work harder to be entertaining than Sara does. (My Mars hair, for example, is a big hit. I've never once seen Sara demonstrate what hair would look like in the lesser gravity and high winds of Mars.) Sara simply stands behind a big kitchen island and talks. Once in a while she walks over to the refrigerator while she's talking. That's about it for excitement. Clearly, people are tuning in for content. Personally, I don't think content about chopping an onion can compete with content about the challenging atmosphere on Mars. Or the creepiness of relativity theory. Or, especially, the scary, elegant, bookkeeping-like certainty of genetic coding. So what's Sara got that we poor science educators don't have?

Well, how about a self-selected audience, for a start. Most people tuning in to "Cooking Live" each night are genuinely interested in learning something about the subject, whereas in the Integrated Science class that I teach for the Honors College at my university, I rarely ever run across a student who is taking the class purely for enjoyment. In fact, it is worse than that. Recently, I've begun surveying non-science majors for their attitudes toward science labs before course instruction actually begins. In particular, I am interested in what student attitudes are toward the labs because I have always intuitively felt (as probably most of us do) that labs should be fun. After all, if our students are not actively enjoying the labs, is there any reason that we should expect them to want to learn about science? And if they don't enjoy learning about science now, under our earnest tutelage, can we expect them to want to continue to learn about it after they graduate and leave the classroom?

The results of my first survey (which consisted of an Honors integrated science class) are shown in Figures 1 and 2 below:

<table>
<thead>
<tr>
<th>Total Pre-Survey</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>HONS 2115-H02 Sp 2000</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I enjoy science labs</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Science labs are fun</td>
<td>6</td>
<td>11</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have learned a lot from science labs</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Science labs have increased my interest in science</td>
<td>1</td>
<td>13</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
I surveyed the integrated science course because I was curious about what kind of audience I was facing as I began my instruction. The answer appeared to be, on the basis of my one-time survey, a somewhat unenthusiastic one. On the whole, if we were to apply a letter grade using a standard grade point average (on a 4.0 scale) to the survey results, the students would give the labs something on the order of a “D” to “D+” for enjoyment. When queried about whether they believe they’ve learned anything in past experiences, the labs fare a little better, earning the grade of “C−.” And as far as actually increasing their interest in science, labs earn the grade of “F.”
The results of the survey intrigued me. I was inheriting a class that had just completed the first part of a two-semester sequence. In the first semester, the labs were the standard “cookbook” labs—start and finish the exercise in one class period; success depends on finding a “known” result (or “verification” labs). This is how science labs were taught to me when I was learning science; it is how I’ve taught labs for many years myself. I was disturbed enough by these findings that I decided to survey two geology labs (my field of study), which are (still) being taught in exactly the same manner in which I was taught many years ago. Here are the results of those surveys:

<table>
<thead>
<tr>
<th>Total Pre-Survey</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 1101-301, -302 SSI 2000</td>
<td>I enjoy science labs</td>
<td>3</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Science labs are fun</td>
<td>4</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>I have learned a lot from science data</td>
<td>5</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Science labs have increased my interest in science</td>
<td>4</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Science labs have helped me understand the methods of science</td>
<td>7</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 3. Pre-lab survey results, GEOL 1101-301, -302, First Summer Session, 2000. Chart reflects a weighted average where Strongly Agree = 3 and Strongly Disagree = 0. Numbers 1–5 correspond to questions 1–5 shown above.

For the physical geology labs, I left out the column giving the students the chance to be neutral in their response (making it more difficult to give their responses a “grade” since, with only four choices, I would have to leave out a letter). In this instance, the
students’ attitudes seem slightly more positive than those of Honors class but still fall dismally short of a spirited endorsement.

On an even lighter note, one very pretty summer day, having spent the morning frittering my time away as I pondered these results and the potential impact on the deeper meaning of science education (the theories of which I, as a scientist, am embarrassingly ignorant), I was overcome by curiosity: just how bad is our problem? I decided to get down to the basics. I grabbed a notepad and ran outside my office, where I randomly selected 105 students as they walked across campus and asked them the following question: if given a choice between going to science lab and sleeping, which would you prefer?2

83% of the non-science majors polled prefer sleeping to going to science lab.3

We (most of us on campus, apparently) are a long way from having students say, “First of all, I just love this class.” Unlike the passionate viewers of “Cooking Live,” our students come to lab not because they are curious to learn something new, but simply because it is a requirement for a grade.4 And worse, most would prefer not to be there at all. Far from telling us how much they love the class, the first question most of us get at the start of lab is “Will we have to stay

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2 The students’ response may have been skewed by my underestimating the attraction of sleeping to college-age people. In picking the alternative to science lab, I was searching for something benign—less fun than rollerblading (who wouldn’t rather do that) and more fun than a root canal. Sleeping seemed like a good choice, but then, that is from the perspective of a forty-three-year-old who resents every minute of her life that is stolen by sleep. The survey would have been better if I’d also asked them if there was any class they would prefer over sleeping. But since I was really only interested in what they thought of my field, this didn’t occur to me. I suppose if I ever get serious about these surveys I’ll have to do a more thorough job. Also, I didn’t run this survey by the Human Subjects Committee first and so had to make my apologies to them later (along with submitting the requisite paperwork) in order to comply with University policy. (I’m not used to gathering data by survey; rocks don’t really have opinions.) Spontaneity bites the dust.

3 63% of the science majors preferred sleeping—a figure I find equally alarming, but this is a problem outside the parameters of this paper.

4 Many of the students polled waffled at first, citing the necessity of going to lab to get a good grade. When I told them they would not be graded on lab, the overwhelming choice was sleeping.
the whole period today?” This is hardly the sign of an eager learner.

Should we care? After all, we all have to do things we don’t want to do. I don’t particularly enjoy having my teeth cleaned, but I recognize it as an important step in the process of keeping them around. Knowledge is good for them, ergo, students should acquire knowledge whether they like it or not. So what’s wrong with force-feeding science knowledge to reluctant learners? (Instead of the “classroom,” we could even call this the “enforced learning format.” Hey...I smell a grant.)

Let’s look at the question from a different perspective. What is it we want to accomplish with a science lab? I think there are two possible answers: one for science majors and one for non-science majors. For many years, I taught a section of physical geology, a freshman lab science course, as if I were teaching to a roomful of science majors. I expounded on things geologic with missionary zeal, thinking that material I was teaching the students was something everyone ought to know when, in reality, many of the things I taught were only things that geology majors needed to know. I invested a lot of energy into the class, and I presume the students (at least the ones who passed) did, too. Then, as fortune had it, I started working in another office with two former students of mine, both of whom had taken geology from me a few years earlier and (allegedly) enjoyed it. A couple of offhand geologic comments I made to them—and their subsequent responses—led me to suspect that, in spite of the fact that they’d both done well in my class, they’d retained very little of the knowledge.

Well! I had busted my gums teaching them that Really Important Stuff, and they didn’t retain it? Once I got over being a tad insulted, I became curious. How much had they forgotten, and were they the only ones? I made up a little test, using some standard questions such as I might have asked over very basic material in my class, and asked my co-workers to take it. I also managed to track down two other former students of mine.

Examples of the “easy” questions are: define the Principle of Superposition; does water go faster around a point bar or cut bank; how does Mount St. Helens differ from volcanoes in Hawaii, etc. “Harder” questions cover things like explaining Bowen’s Reaction Series and how artesian wells form. It turned out that it made no difference whether the questions were “easy” or “hard”; the former students missed nearly all of them uniformly.
former students and asked them to take it as well. In addition, I recruited a woman who’d taken someone else’s geology course. All of them save one had earned an “A” in the course; the exception had earned a high “B.” All of them were non-science majors and all of them had taken geology within the last five years. All of them (allegedly) enjoyed the course.

None of them passed. In fact, nearly all of the questions were answered incorrectly or not at all, resulting in an average score of 13 out of a possible 100. They had retained less than 15% of what they’d labored so hard to learn.  

I suspect that this is not unique to my geology classes. And, is anybody really surprised at this result? I’m willing to bet money that people who study things like long-term memory could have predicted this right down to the percentile.

Admittedly, this pop quiz was given to a microscopic sample size. It is difficult to find former students, and at the time I wasn’t interested in doing a real study, I was just satisfying my curiosity. Nevertheless, it got me thinking about the purpose of my teaching. If it is about them learning Really Important Stuff for life, I might as well pack my duffel and go work on a tuna boat because that clearly wasn’t happening.

All of this—working very diligently to teach the students content only to have them remember very little of it—puts me in mind of my favorite zen koan:

“A man was rowing his boat upstream on a very misty morning. Suddenly, he saw another boat coming downstream, not trying to avoid him. It was coming straight at him. He shouted, ‘Be careful! Be careful!’ but the boat came right into him, and his boat was almost sunk. The man became very angry, and began to shout at the other person, to give him a piece of his mind. But when he looked closely, he saw that there was no one in the other boat”

Usually, when I meditate upon this parable, I do so to remind

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6 Actually, one person skewed the curve with a whopping 31%. When that anomalous datum is removed, the mean is 8.5%.
myself that it is useless to become agitated over mindless forces of nature like, say, timely reimbursement from the university for travel expenses. But since I like it and it is the only zen koan I have memorized, I’m going to use it in this instance as well to illustrate the futility of expecting a student to retain much in the way of content beyond the moment the class is officially ended. I can care deeply about the need for them to know facts – they can even care about it, too; it just probably isn’t going to happen in the long term. Maybe having that expectation is like shouting at an empty boat.

To sum up all my surveys and pop quizzes, not only are students not having any fun in their lab science (see above), they apparently are not retaining much content in the long term, either.

What’s it all for, then? Since coming to work for the Honors College (which, by its nature, allows me a lot of room to re-think my approach to teaching), I have thought long and hard about what characterizes an Honors graduate. Is it someone who knows a lot of Stuff at the end of four years? Yes, certainly we hope for that. But I think I want more than that—no, something better than that. I want to take my non-science-major science-phobes and turn them into people who are inquisitive about the natural world. What I want to accomplish, I have realized, is to turn them into eager learners, just like those wannabe cooks tuned into “Cooking Live.” I want them to want to know. I want them to go on to graduate from the Honors College and the University hungry to learn more. I want them to be interested in science now, and forever. If they are, they’ll be able to learn the facts they need—even when I’m not around. Boring them in lab is not the way to accomplish this.

This puts me in mind of another zen saying: “Scratch first, itch later.” I don’t really know what this means. (That is often the way with me and zen sayings.) But I’m going to use it in the context of: teach them stuff first, let the interest come later. I think this is exactly backwards (my apologies to the zen master). What is the point of scratching if you don’t have an itch?

Admittedly, my surveys are few so far. Nevertheless, on the basis of those I’ve given, I think they are confirming what I’d begun to

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suspect (and education people probably already know) after several years of teaching: students don’t seem to be enjoying science labs. They don’t seem to be learning much, either. Maybe the way we’ve been teaching science has been killing the itch altogether. Science labs should be a sort of curiosity shop—a place where we build wonder and amazement through tinkering and puttering. This, instead of a place where students go through the listless motions of verifying information the teacher has decided they need to know.

Okay, so we have to create an itch. Just how do we go about doing this?

One day, not long ago, I picked up an issue of Scientific American. In it, there was an article on spinal cord injuries. It was written as if the reader had no prior knowledge of the physiology of the spinal cord, let alone what actually causes paralysis when an injury occurs. The intro was direct and compelling. Like a somber litany for sailors lost at sea, it listed one paralysis injury after another: gymnast Sang Lan, gunshot victim Richard Castaldo, football player Dennis Byrd, infant Samantha Jennifer Reed.

Intrigued by the title, “Repairing the Damaged Spinal Cord,” I had originally picked up the magazine and started to read the article for the same reason anyone else would—hoping that there was hope, fearful that there wasn’t. We all want to believe that there is something—anything—that we can do to make something so terrible all right again. The title and the teaser above it, “Once little more than a futile hope, some restoration of the injured spinal cord is beginning to seem feasible,” promised something of that, so I was curious enough to read. The introduction, by putting human faces on the tragedy, drew me in further.

By the second page, I had learned about the following: neurons, dendrites, axons, synapses, the descending motor pathway of neurons which controls the smooth muscles of the internal organs and the striated muscles, the ascending motor pathway which transmits sensory signals from the extremities and organs, the transducer cells that allow this to happen, white matter, myelin, glial cells, astrocytes,

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microglia, and oligodendrocytes. There was also a diagram that illustrated the four divisions of the spinal cord as well as each of the associated nerves and what they controlled.

I knew and understood the roles of each of these items by the second page of text, and still, in spite of the fact that it was a hefty amount of information to swallow at once, I never lost interest in the article. Now, people who know me well will tell you that I have the attention span of one of those glial cells. This is especially true when it comes to reading science writing. So why was it that this article could keep my attention even through the fairly technical, not terribly exciting information that I needed to understand the rest of the story?

First of all, it led with relevance. It didn’t start with the definitions; it provided them after I was hooked. Furthermore, it didn’t belabor the technical stuff, instead providing only exactly what I needed to know. In short, it provided me with plenty of meaty content, and I was willing to learn it, but only because I had a bigger question that I wanted answered, namely: can we reverse paralysis?

When I first started teaching geology, I had a newly-minted graduate student’s outlook on teaching, which was something like: I’ll show these students what it is really like to be a student! By this I meant, of course, what it is really like to be a graduate student. But I wasn’t teaching fellow graduate students; I was teaching freshmen. And, unlike me, they weren’t even really interested in the subject; they were mostly taking the course to fulfill a lab science requirement. Worse, since I was teaching geology, they were really taking it to avoid having to take physics or chemistry.¹⁰ No matter; I was going to show them what “content” was all about. Geology is chock full of interesting things (like volcanoes, and floods, and evolution)—but they needed to know the basics (like silicate structures, and friction coefficients, and the names of all the delta shapes) before we could get there!

I think also, if I’m to be honest, I was trying to impress the “real” faculty (I was a mere doctoral student at the time) who’d entrusted me with the job. I certainly didn’t want them thinking I was some

¹⁰I know this because I always polled the students on the first day with the question, “How many of you are in my class only because you are avoiding physics and chemistry?” About thirty to fifty percent of the students usually “fessed up.”

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lightweight who was going to be too easy on the students. My students were going to know “A Lot of Stuff” if they made it through my class. And that, in turn, would show everybody what a great teacher I was.

I was pretty good at teaching a lot of stuff, in detail. I could probably spend an hour and a half on delta shapes and their names alone. (Luckily for you, delta shapes are outside the parameters of this paper.)

I don’t want to believe I bored my pupils silly, but I think probably (at least sometimes) I did. Looking back, I think, too, that I bored them needlessly. Delta shapes and friction coefficients are important to somebody. They aren’t important to non-science majors. And, as I demonstrated above, once the students left my classroom they didn’t remember that sort of thing anyway.

Old belief systems die hard. Even now, when I hear colleagues say that “fun is all well and good, but I can’t teach the interesting stuff until they learn the basics,” I feel a twinge of guilt for believing that some of those “basics” are overrated. Or if they are not always overrated, then sometimes they are over-taught. To wit, in the magazine article mentioned above, I learned an awful lot of basics about the spinal cord in two short pages that probably took me no more than five minutes to read. Pause for a moment and look back over that list of items and ask yourself how much time we (as scientist/science teachers) might have spent on those basics in the classroom setting before we got to the good stuff. In my olden days, I probably could have milked those topics for a good six hours (pretending, for a moment, that I taught physiology instead of geology). And I could have rationalized every one of those interminable hours by saying, “the students need to know and deeply understand these things before I can talk about paralysis in a meaningful way.”

Let me ask a question here. Are the students interested in myelin, or paralysis? Which one is important to them? Again, these are non-science students we are talking about. (I’m not saying that a science major’s education shouldn’t also be interesting—I’m saying that the content might be different. I want the students going on to be doctors or research biologists to know about myelin in intricate, intimate detail. I want them to marry myelin.)

If a magazine article can teach me the necessary basics in two
pages, why can’t I do the equivalent in the classroom so that I can get on to what’s really important? Remember, the authors intrigued me enough at the start that I was willing to do the work to get to the payoff. They made me ask the question first. They made me want to know.

All of this leads me back to teaching science labs, the subject of my surveys in the section above. As the coordinator for our Honors College Integrated Science course, I am obsessed with the labs. Labs are where we should be turning them into science fans. Labs are where we should be awakening a life-long interest so that when they walk out of our classrooms and down that long aisle to pick up their diplomas, they do so eager and prepared to investigate Really Important Stuff without us prodding them to do so. If we can do this, we don’t have to worry about whether or not they are taught (or remember) all of the “necessary” basics. They will learn the basics as by-products of their curiosity.

Here is the problem: most science labs are boring. For example, take your average physical geology lab manual with the standard cookbook exercises that cover such topics as minerals and mineral identification, igneous rocks, sedimentary rocks, metamorphic rocks, maps and aerial photos, and (my personal favorite in the Most Dull category) mass wasting. I picked one of these exercises—sedimentary rocks—at random out of a typical lab manual. Now, I happen to like sedimentary rocks—a lot. Sedimentary rocks are all about my favorite geologic things, like stream and wind processes. Fossils (and lord, I love fossils!) are preserved in sed rocks. So I might be expected to think this lab was interesting.

For the lab exercise, students have to learn the different classifications of sedimentary rocks (for the most part, this is about mineral content and texture) and the origins of the different rocks. They would be given a box of rocks to identify using flow charts and descriptions, and they would probably have to answer some questions at the end of the exercise about the things they’d learned. All of this would take about two hours of their time (learning to use the flow chart and reading the descriptions of the different rocks) and would be as dull as, well, a box of rocks.

Who cares? Who cares if a history major can tell the difference between gypsum and limestone? Especially when the interesting
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stuff doesn’t require them to know it? Don’t get me wrong – if you want to look for reef fossils, you’d better know that limestone is a reef rock whereas gypsum is not. But there, I just told you that. How hard was it to learn that information? And what did it have to do with memorizing mineral content or composition? If a student wants to know where to find reef fossils, we could just tell her: “Here, this is a limestone. Most limestones represent the reef environment. If we were going hiking, where would we look for it? Where do reefs normally occur? How does a reef come to be in the middle of a continent? And now I’ll show you how you tell it from other rocks that might look just the same. By the way, did you know that it fizzes in acid? Why do you suppose that is?”

Lead with the question, not the content. Make them want the content to answer the question. You gotta have the itch before you want to scratch.

At the beginning of this essay, I wondered why people watching “Cooking Live” seemed to enjoy learning so much more than our students. Part of the answer, I believe, is the self-selected audience. Students in our labs are not there by choice. But there’s probably more to it than that. In the book Women’s Science, Margaret Eisenhart and Elizabeth Finkel argue that students turn away from science when their education is organized in such a way that it lacks passion, provides no context, and is relentlessly (my wording) rational.\(^\text{11}\) My wonderful colleague, Gerald Skoog (who, unlike me, actually knows something about educational theory), rightly points out that cooking is “passionate, contextualized, and probably irrational and tied to values!!” whereas memorizing minerals is not.\(^\text{12}\)

To be honest, I think a lot of our labs are busywork. I don’t think that we intend for them to be that way – I just think that is how it turns out because of the traditional cookbook structure. We labor to teach them the mineral content of gypsum, and they forget it before they’re out the door because it is boring and irrelevant.

On the other hand, suppose I lead with a question. Suppose I take my students out to the field and, in between hiking and eating our


\(^\text{12}\) Personal correspondence.
peanut butter sandwiches, show them gypsum and say: “Look at this fantastic mineral!" What is it? Why is it here and not over there? Somebody give me a hypothesis and we’ll test it. And by the way, did you know that this is the same stuff that’s in sheetrock?”

Suppose I give them, not one three-hour lab, but several weeks to explore this question so that they really could formulate and test a hypothesis. Maybe they would even have to go out into the field on their own! Maybe they would have to build something—like, say, a flume—to test their hypothesis!

Okay, it is true that they wouldn’t get to all that other material in the lab manual. Who cares? They won’t remember it anyway. And it’s BORING. We aren’t going to be turning any of them into junior scientists that way.

Here is what they might learn instead: how to ask a question. What question to ask. Where to look for answers. Along the way, they also learn about gypsum, and restricted basins, and evaporates, and ripple marks, and cutbanks, and....

And—here’s the best part—they might even have some fun.

Recently, I’ve tried this approach (what I call a sort of “magazine approach,” but which is properly called an “investigative,” “project,” or “problem-based” lab in the education literature) with my section of Integrated Science lab by switching from exercises that begin and end with each lab period (the “cookbook,” or “verification” approach) to a long project that takes several weeks to complete. This project is one of the students’ choosing, though the choice is strongly guided by the instructor. The first semester I tried this, I wasn’t interested in doing a study on changing students’ attitudes toward labs. I was just messing around in lab trying something new. What caught me by surprise was how much more engaged in their work the students seemed to be. As a scientist, though, it makes me uncomfortable to call this an unqualified success on the basis of the anecdotal evidence that they certainly seemed to have fun. So this past spring I began to collect data by doing a pre- and post-semester survey on their attitudes. The results were promising enough that we are switching to

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13 Selenite and satin spar gypsum are both striking and noticeable in the field. Gypsum is a regular among the rocks and minerals students frequently bring in for me to identify. Of course, often this is after they’ve already “learned” it in the lab.

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project-based labs for all of the labs in Integrated Science.

The projects that I’ve tried so far include both geology and biology studies. In the geology study, students were taken to the field and shown a sedimentary structure (in this case, pebble imbrication). They described what they saw, and from the information they gathered, they went back to the lab and formed a hypothesis. (They were given enough background information about stream systems to do this, but the instructor did not help them form a hypothesis.) The students then designed an experiment to test the hypothesis, ran the experiment, collected the data, and analyzed the results.

Not one of the groups came up with the correct hypothesis—not unexpected, since pebble imbrication is somewhat peculiar.14 It didn’t matter. In science, if we knew what the answer was before we started, we wouldn’t bother trying to find out. This was a point the teaching assistant and I made repeatedly to the class. Proving a hypothesis wrong is just as valuable as finding evidence to support it. Data are data; there is no “incorrect” answer (unless you did your experiment incorrectly, which is a different problem). This bothered them at first. Honors students are used to success (and to the notion that there is a “correct” answer). To tell them that they might get something wrong and that it was perfectly okay was a different way of looking at things for them. But, it is the normal way of doing things in science.

Interestingly, all of the groups managed (through no planning of mine) to illustrate various things that can occur with a study: getting good data that prove a hypothesis false; designing an experiment that fails to adequately test the hypothesis; and getting the “wrong” hypothesis but the right results from the experiment (i.e., misleading data).

After it was all over, I told them how pebble imbrication occurs. It took all of five minutes and they were happy to have the information, but we all knew it wasn’t really the point of the exercise. Maybe I should have spent the semester teaching them a lot of geo-factlets like this. But I think the teaching assistant and I taught them something

14 Which is partly why I chose it. I wanted the students to realize that sometimes science is not about curing cancer, but about satisfying your curiosity concerning something peculiar.
more important than a loose collection of facts. I think they learned something very special about science that they might not have otherwise.

Emboldened by what appeared to be a successful way to teach some of the more intangible things about science, I decided to try a project-based lab again in the spring of 2000. (I also started an assessment program to see if it was really working.) This time the project was a biology experiment. Pigeons are poisoned each year on our campus as part of an eradication campaign, something that the students find quite disturbing. They chose to do a study that would evaluate the effect (if any) of the poison on non-target species of birds.

The hypothesis was this: non-target species are at risk from eating the poisoned corn put out for the pigeons. The students decided to test this by scattering corn in two areas where the poisoned corn was normally placed and monitoring the sites to see whether non-target species were eating it. They set up teams of three to four people, each with different roles in data collection. Each site was monitored by a team for 30 minutes, once a day. There were three teams so this occurred three times a day for two weeks. I emphasize this last part for a couple of reasons. The students were the ones who chose to monitor the sites this extensively. This is well above the amount of time that they would normally spend in a lab each week, yet they did this voluntarily. It is a far cry from their asking “Are we going to have to stay the whole period today?”

About halfway through the experiment, I got a message that two students were waiting in front of the Honors offices to see me. When I went to greet them, I found a couple of very excited young women. They’d seen their first spring warbler while they were collecting data and

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15 And the truth is, they were spending so much outside time during the semester learning to identify birds, researching the nature of the poison that is used, buying cracked corn, monitoring the sites, writing reports, etc., that in the second part of the semester I only required them to show up in lab briefly each week so that I could check their progress. My role was mainly to teach them bird identification and experimental design. Otherwise, the project was almost entirely student-driven.

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couldn’t wait to tell me. These were students who didn’t even know (or care) what a house sparrow was at the start of the semester, much less how to design an experiment and evaluate data.

Aha! Now I get it! Lead with the question. Make them want to know the answer to an interesting question, and they’ll gather the knowledge you want them to as a by-product of their curiosity.

Aside from anecdotal evidence, survey results seem to indicate the success of this lab (Figure 4):

<table>
<thead>
<tr>
<th>Post-Survey HONS 2116 H02, Spring 00 Bird Study Project</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoy science labs</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science labs are fun</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have learned a lot from science labs</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Science labs have increased my interest in science</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Science labs have helped me understand the methods of science</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. Pre- and post-semester survey, HONS 2116-H02, Spring 2000. Numbers 1-5 correspond with questions 1-5 in the chart above. Bar chart reflects a weighted average where Strongly Agree = 5 and Strongly Disagree = 1. See Part One for the pre-survey for the answers to the questions.

The students’ written comments were interesting as well, citing the new respect they had for scientific work, a better understanding of the

16 But, as they hastily assured me, they’d finished the two requisite 30-minute monitoring periods before rushing over to tell me. Besides being thrilled to see their first warbler, they were worried that it might be at risk. I broke one of my rules (pretend I don’t know the answer to their hypothesis) and reassured them the warbler would not eat the corn.

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methods of science, an increased awareness of their environment, and how much fun they had.

And incidentally, non-target species ate the corn put out in the study.

It’s too soon for me to tell how effective using a project-based lab (compared to the traditional cookbook lab) really is. The results from my lab have been encouraging enough for us to try it for both sections of Integrated Science for the entire two-semester sequence this year. We hope we’ll be able to gather some definitive data from this tentative experiment in changing our pedagogy. For now, though, the idea of starting with a question that interests the students and going from there appears to have promise. I am encouraged. Maybe, in the Honors Integrated Science class, we are one step closer to teaching students to want to know—one step closer to turning our lab into a true “curiosity shop,” where they tinker, and putter, and explore their own way to science knowledge.

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