Teacher Resources: Scientific Method

Teaching the Scientific Method

The scientific method is usually the first thing that gets taught in a chemistry class. The reason for this is simple: Generally students don't have a good feel for what scientific inquiry is, and usually think that a scientist is an old bald guy with a lab coat who plays with steaming test tubes and flasks (and probably the odd monster or two). Unless we teach the kids early on that scientific inquiry is something that everybody does, they'll cling to this idea and use it as an excuse to explain why they can't understand science.

I do the milk lab on the first day of school. I've found that if you hit the kids early with a lab (especially one that doesn't look like a real lab at all), then they become far more receptive to the idea of doing labs for the rest of the year. I like to think of labs as being just a fun activity where the students get to mess around with stuff to figure out how chemistry works. By starting with the milk lab, kids are painlessly introduced to scientific inquiry in a low-stress environment.

Of course, after the lab is done and the kids have cleaned everything up, it's time to introduce the steps and details of the scientific method. This is where the handout comes in: It gives the kids a quick description of the scientific method, with some space they can use to write their own notes. When talking about the scientific method, I like to let the kids come up with their own examples and solutions – inevitably, they use non-chemical examples, and this makes them more comfortable in a class that their friends and parents have told them is really hard.

The scientific method is usually a good unit to start with because it teaches chemistry without mentioning chemicals. When I took chemistry in high school, I hated it from the first day because the class started with a big chemical demonstration and used the chemical terms from day one. By making chemistry low stress and by using words they understand from the start, you make the kids more comfortable in the chemical world. And that's when you hit 'em with all the science stuff.

Doing the Milk Lab

Equipment (will equip 30 students):
1 half-gallon bottle of skim milk
1 half-gallon bottle of whole milk
1 half-gallon bottle of 2% milk
A quart of half and half e) A quart of whipping cream
20 petri dishes
3 small bottles of food coloring (one red, one green, one blue)
12 small disposable pipets
1 small bottle of dishwashing detergent
1 class set of safety goggles

Safety issues:
The milk lab presents no safety problems and can be used at any level with any student. It's this safety factor that makes it an ideal first lab – unless the students feel some strange desire to drink the detergent or eat a broken petri dish, there's not really any way that you can hurt yourself. However, I want to stress that the first lab of the year is a good time to get the kids used to wearing goggles. A little bit of hassle here will make future labs a lot safer.

Room destruction factor:
Moderate. Although it's impossible to trash a room using this lab it is easy to leave semi-permanent food-coloring marks on every exposed surface. One way to minimize the room destruction factor is to use disposable pipets to hold the food coloring. If you use the plastic type, you can prefill them with a 1:4 food coloring/water mixture and melt the end shut. This way, the maximum amount of mess that can be made is one pipets worth. One more thing: When milk (especially the heavy stuff) dries, it's sticky and disgusting and almost impossible to see. Make sure that everyone is very good about cleaning up any drips or spills from the tables and floors before you let them go.

Things to focus on:
Students come into the year after having heard about how terrible chemistry class is, and how so-and-so got an F even though he worked really hard thanks to that mean teacher. To combat this negative attitude about chemistry, give the kids minimal instruction at the beginning (focusing on where the "chemicals" can be found and safety) and then let the kids do whatever they want. If the kids find out that they really have a lot of leeway in what they can do (especially in the "Do your own original experiment" part of the lab), they'll feel a lot happier about having to do the lab.

Won't it affect classroom control to have the kids run loose the first day? The answer is yes, but only if you let the kids fun wild. Let the kids do whatever they want for their original experiment, but keep a tight lid on any disciplinary issues. Horseplay and goofing-off should be tightly punished, especially in light of the

fact that it's the first day of school. The kids need to be given the selective freedom to do their own experiment but not the freedom to act out as they wish.

The other main thing to focus on is the phenomenon of the needy kid. You know him/her/it: He/she/it's the one that stands at their lab table reading the procedure over and over again as if the paper will come to life and start doing the lab by itself. When it becomes clear this isn't going to happen, the kid becomes neurotic and comes up to you asking dumb questions (example: Is the food coloring that blue liquid over there labeled "food coloring"?) In this lab, the needy kid is likely to drive you crazy because the whole second part of the lab is involves designing their own experiment and predicting what's going to happen. ("But how will I know what's going to happen? I never took chemistry before?") The best thing you can do with the needy kid is to tell them to be creative, try their best, and come up with something on their own. Eventually he/she/it will become tired of getting told to figure it out him/her/itself and go tell his/her/its friends that you're a mean teacher who won't help him/her/it. But the important part is that this kid will finally get the picture that they can do stuff on their own, and hopefully this will make life easier in the long run.

Clean up:
Everything can go down the sink. After all, it's just milk, food coloring, and soap.

Solutions for the Milk Lab and Milk Lab worksheet:
OK. There's good news and bad news. Let's start with the good news:
This lab and worksheet are easy to grade, because either the kids did the scientific method or they didn't. Aside from that, pretty much anything is the right answer. If they said that they thought putting extra milk in the petri dish would make the food coloring mix faster, then either it did or didn't, and either way, the experiment is valid and they can get the points for it.

The bad news: Grading the lab and worksheet is all a semantic issue. The correctness of the answers is based as much on how they say what they say as what they say. For example, if they give as an example of a hypothesis that: "If I add twice as much food coloring, the mixing will happen twice as fast", this is more correct than giving a hypothesis that states "More food coloring means more mixing". For students who are good at expressing themselves, this lab is a piece of cake. For students who don't write with precision, this lab is a nightmare. Make sure that before you do the lab you point out the importance of using precise language to minimize this issue.

More bad news: On the worksheet where it asks them to come up with a solution to the cat problem, be prepared for some very strange and deliberately provocative answers. My personal favorite, from a kid at our ED center: "If you shoot the cat, your uncle can go on vacation," followed by a description on the proper caliber weapon, et cetera. When this happens, smile, move slowly, and never show any fear.

Actually, about the best thing you can do is to ignore this kind of behavior. There's always some smart guy who wants to come up with a disturbing example for the scientific method. The best thing to do is to show no reaction and to assess whether the kid is a threat. If not, then ignore it. If there's any doubt at all, report the kid to security. Better safe than sorry. Important note: If you do decide that the kid's harmless, then give full credit for strange, but technically-correct, answers. Remember, we're looking for the scientific method, no matter how weird the example. However, feel free to talk to the kid about their use of inappropriate subject matter.