CHB03 5:40-5:50 p.m. Data Matters: We Insist on Successful Results

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Abstract: The major reason we require that all 9th grade students take physics is to learn the importance of lab to understanding science. Since accurate results best illuminate major laws, we evaluate students during lab practicums on the quality of their results. As a consequence, we have found that students "sweat the details" more in lab, repeat labs on their own time to gain confidence, and talk more to us and each other about the quality of their work. Our focus on results has increased interest in science as measured by (among other things) larger enrollments and AP science scores. Of special interest may be the fact that we are an all-girls school.

Like many high schools, we start with physics first. But unlike many schools, we do this because we think physics is the best way to learn how to effectively perform labs. We emphasize experiment because the most powerful teacher is not me or the textbook – the most powerful teacher is a good lab.

For us, then, the lab is not one more area for assessment: the lab is central to all we do. Every test, including paper-and-pen tests, focus on the lab. This emphasis is doubly important in our high school, for we are an all-girls school, and many of our girls arrive with lots of so-called knowledge but little lab experience. This has significant consequences: why do females still make up a modest fraction of the engineering and physical science majors? We suspect a major cause is their lack of serious lab experience. Our challenge is thus simple and compelling: we need to provide our girls with a lab program that teaches well. With this in mind, I will outline five keys we found to delivering such a program.

The first key is that results matter. When a girl completes a lab, she can expect from us one of two responses to our girls: either her results make sense or she needs to redo the lab. There is no point drawing conclusions from faulty lab work. This means that we design lab periods to allow time for repeating tests. And, at least for the first month or two, they need that extra time. What we never say is, "Here is what should have happened." If we trust the physics, then what should happen <u>did</u> happen. And if it didn't, we fix the lab.

Our second key is to display the data. Early into the lab, we look at the posted results and evaluate our findings. Yes, my students find this a little awkward at first. Bad results stick out. But our students quickly realize that evaluating data is the job of science. They soon learn to monitor their progress and make adjustments along the way. And they even start to take some pride in their performance and to sweat the details of getting good results.

Of course, students cannot get better without practice, so our third key is to perform many, many labs. We complete 63 a year, or about two a week. Some of these labs are quite basic and many employ a previously-used technique. We stress such skill-building. One critique I have of college labs is that students often use an exotic piece of equipment they encounter only once. This doesn't work in high school. For example, you don't get good at reading a scale in one try, so we have six labs that require frequent use of our balances. The students make mistakes at first; eventually, they become competent. The more students use the apparatus, the more they understand what it can and cannot do.

For the students to learn from the lab, we need to steer their attention, so our fourth key is to direct students as to how to present and interpret data. I realize this means the students don't decide on their own how to organize data or what calculations to make. That's a loss. Still, our thinking is that our students need a year of being guided to get the hang of the work. What is more, our approach means we can focus more of their energy on answering questions about the lab, which is where the real learning occurs.

Our fifth and final key is to have the labs build toward periodic capstone performances, that is, major labs that require the skills and knowledge of preceding labs. A good example of this is when study energy and build toward having the students predict the velocity of a cart as it moves up and down a ramp while connected to a spring. This lab requires that the students understand and apply knowledge about gravitational and spring potential energy as well as kinetic energy. It often takes several tries to get results consistent with predictions. But when the girls do get it right, they see the power of the concept of conservation of energy.

Our focus on what students learn from lab has stirred our thinking. We wonder if it would make more sense to stop debating what topics should be taught and instead determine the 25 major labs that all physics students should complete. Right now, my list would include

- measuring the conservation of momentum in two dimensions,
- predicting the behavior in an electric circuit with series and parallel elements,
- and conducting the double-slit interference lab.

You no doubt have your ideas. A list of the 25 essential labs might be a better guide for schools than a vague list of concepts and skills.

Finally, I should note that I don't view anything I have said as innovative. All of these ideas spring directly from the one high school physics program that got it right, and that is PSSC Physics. It stuns me that this program has fallen so far out of favor that the book is out of print. The experimental focus of PSSC Physics was front and center. The best test of physics can be found in the lab; let's concentrate our energies there.