Teaching Philosophy
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Over the past 10 years, I have had the opportunity to do a significant amount of teaching, particularly during my time at Swarthmore. My teaching philosophy has certainly evolved over the years since I was a graduate student and will no doubt continue to change as I try out new things. It is also intimately tied to my teaching experiences at Swarthmore and the University of Toronto, the former being a smaller teaching environment than the latter. Overall, I simply love to teach and I take great pride in it. I want to make a connection with the students and have the lecture or seminar be an interactive dialog between us. A large part of my teaching philosophy centers around making this connection. Below, you will find several sections that go into more detail about the aspects of my teaching philosophy about which I feel most strongly. I also address my expectations in teaching and my philosophy on evaluation.

The Classroom Environment

What I have found to be vital in teaching is developing a classroom environment in which the students feel at ease asking questions and providing their own answers to questions I ask of the class. It is certainly the case that the smaller the class size, the better; however you have to work very hard to make the students feel comfortable, especially early on in the class. Most of my teaching has been in introductory courses, where many of the students are new to the College and may not feel confident enough to speak up. Getting the first questions on the first day can be the hardest part of the entire course. I usually start things off by asking them, each in turn, to tell me their names and answer the question: “If there was only one thing you wanted to learn from the course, what would it be?” I write down all the answers and say I’ll do my best to get to all of them. A few of the students will start out by saying “This is probably a stupid question, but…” I tell them that those are my favorite, because they are often the most interesting and keep me on my toes. After this initial barrage of questions (which takes less time than you might think), I find the atmosphere is a little bit more relaxed. It’s still not completely where I want it, but it’s a good start. And these questions are a fantastic resource for seeing what’s on everyone’s mind.

When I ask students a question in class to promote discussion, I always silently count to 10 before I prod some more. They have to have time to think about it, after all. When someone answers and they are on the wrong track, I always let them finish their answer completely. I won’t correct them at first, but rather ask the rest of the class what they think. Often, someone else will point out what is wrong, or with a little prodding, the student realizes their mistake. But I always thank the student and point out what was right and how it helped with the discussion (which can sometimes be very challenging). What I want to do is show everyone that getting the wrong answer is part of learning and that missteps can help us learn. For instance, when we first cover relativity and talk about the non-simultaneity of events, and I ask what happened when, hardly anyone gets it right the first time. But a discussion on where they went wrong or what bad assumption they made can really help everyone else understand the material.
Enthusiasm

The next thing I have come to rely on in my teaching is my enthusiasm. I find all areas of physics and astronomy fascinating and many of my students have commented to me that it shows. I love to teach because it gives me a chance to show everyone all these amazing things and maybe impart to them some of the appreciation and enthusiasm I have. Apparently, I can even get excited about the existence-uniqueness theorem of differential equations (again, based on comments from one of my students). We, as educators, are in a sense ambassadors for our disciplines. We can’t expect students to be enthusiastic about learning something when we are not enthusiastic about teaching it, whether the subject matter is the Grand Theory of Everything or the existence of a solution to a differential equation.

As much as enthusiasm helps, I find it also helps to make connections between the subject matter I am teaching and other disciplines. This has been especially important in a liberal arts setting like Swarthmore. As excited as I get about the discovery that the universe is 14 billion years old, that has very little direct impact on my students’ daily lives. However, I can then point out that if the universe were just a little different, it would have ended long ago in a Big Crunch or expanded so fast that stars could not form. We wouldn’t exist. Why, out of all the different possibilities, did the universe “choose” initial conditions that would allow life to begin? These are questions, philosophical as they might be, that students can really get into.

Another way I try to make the students more connected to the subject matter is by actively involving them in demonstrations and labs with real data. When I first taught a course on cosmology, I used a computer-based lab which simulated a telescope. The students could obtain spectroscopy of fake galaxies, measure the Doppler shift, and measure the expansion of this fake universe. It was hard to get excited about fake galaxies with a built-in fake result (there was even a field with the faces of the software’s authors instead of galaxies). While the lab imparted the pedagogy, it fell seriously flat in imparting enthusiasm about observational cosmology! What I did was re-design the lab using the Sloan Digital Sky Survey (SDSS), an online archive of real data. The student can point and click on a galaxy and obtain its spectrum. The student can choose which galaxies to pick. They obtain their own measurement of the expansion rate and age of the universe, which is very real (though highly uncertain). While hunting for the galaxies, they come across colliding galaxies, quasars, galaxy clusters and other exotic objects, which they can print out and save. There were labs where I had to kick out students who were just scanning the sky for fun long after they were done collecting their data. For more senior astronomy students, I’ve designed labs that get them on the roof and using the telescope on their own. It’s a lot more fun when you control where the telescope points and you collect the data. This requires a lot of time (especially if you only have one telescope), but it is worth it, because you learn something better when you do it rather than seeing someone else do it. I will continue to develop labs that either use existing real data or ones where the student collects the data herself or himself.

Using Demonstrations

I am a big fan of in-class demonstrations. They break the class time up and give the students a break from writing. They are also very effective in showing students concepts you have been talking about. However, I find it works best when the students are actively involved
and there is research that bears this out (Crouch et al., Am. J. Phys., 72, 835). I always try to have them make a prediction about what will happen. If there is disagreement among the students, I have them talk about it. Only when I’m sure everyone has thought about it sufficiently do I go ahead. For example, when teaching the equivalence principle, I use a plastic bottle filled with milk and in which I have drilled a hole through the bottom. I then let go of the bottle and because it is in free-fall, the milk ceases to shoot out the bottom. Before I let go, however, I ask them a series of questions. What will happen when I take my finger off the hole? Why would the milk shoot out the bottom? What will happen when I let go of the bottle? How do you know? I find they “get it” more easily if you take the time to do this.

I’ve also found that some demonstrations can be very confusing and often could be improved. A classic demonstration I often use when teaching general relativity is a massive object warping the surface of a rubber sheet. You can see how initially straight trajectories are curved around the object and that you can get orbits just from curvature. However, the confusing part is that we are 3-dimensional beings looking at a 2-dimensional surface. If we were 2-dimensional beings living on the surface of the sheet, we wouldn’t see the warping. To illustrate this, I connect a video camera which is suspended directly over the sheet. This way, you lose the perspective and when you add a mass to the rubber sheet, you cannot see the warping (if you get the lighting right). Now a marble very mysteriously orbits the mass for no apparent reason. This was much more effective and in general I always try to improve on demonstrations.

My Expectations

I try to communicate very clearly to my students what my expectations are. Of course, this will depend on the course being taught, but there are many common themes from course to course. First and foremost, I want my students to get the “big picture”. For instance, in my introductory astronomy course, I want them to better understand not only how the universe works, but how scientists, in general, work to expand their knowledge. I want them to learn what good science is and how to distinguish it from pseudo-science. In teaching mechanics, it’s great (and indeed essential) that the students can solve problems, but I also want them to see how conservation laws arise out of the symmetries in nature or that complicated problems involving vector quantities can often be reduced to simpler problems involving scalars, a concept that enters all areas of physics. This philosophy is reflected in my problem sets and exams, where I tend to ask open-ended questions, where the student has to pull together different bits of knowledge to answer the question. For instance I might ask “Is there life elsewhere in the universe?” Of course, no one really knows the answer to this question, but the student, using what he or she learned in class, can form an opinion and argue it one way or the other and that is what I want to see.

I also want my students to be critical of the material I present. I don’t want them to take what I say in class at face value and simply accept it as a fact. One thing I point out very early is that you can never prove that a theory is true in science. One of the things that makes a good scientist is a critical eye, especially when it comes to one’s own research. Some of the most important discoveries in physics came from researchers being critical of some established theory. Early on in my graduate courses, I was fortunate enough to have a professor that made us question everything, and it stands out in my mind as one of the
most important learning experiences in my academic career.

Evaluation

One aspect of my teaching philosophy that has undergone a substantial shift is the subject of evaluation. Having started out in a large university setting, where the bulk of the grading is done by teaching assistants and a good deal of weight is placed on the term work rather than the final exam, I tended to put less emphasis on the final in my own courses. At the University of Toronto, there are even regulations that limit the weight of the final exam in any course. At Swarthmore, where I felt a great deal more freedom, I have little by little swung the other way. My philosophy regarding term work is that it is mainly a diagnostic tool for students to figure out which topics they understand and which they need to work on. I also want the students to work together on problem sets, as they can teach themselves quite effectively. Consequently, I feel that problem sets should be weighted significantly less than exams that evaluate the students as individuals. And yet, if a student had a lot of trouble on problem sets and mid-term exams, but used them as a learning tool and pulled it all together for the final, I consider that a success and would rather give the final a higher weight. What I have come to use is two grading schemes, one that puts more weight on the term work and one that puts more weight on the final. I give the students the larger of the two. The difference is seldom significant and does not lead to grade inflation, yet when there is a large disparity, it has almost always been the case that the student performed significantly better on the final and I feel the final grade is more in line with my expectations.