Teaching Philosophy

My goal as a teacher is to approach learning from the students' perspective. Although several years separate me from my undergraduate experiences, the memories of struggling with learning difficult concepts are still fresh in my mind. From these experiences, and many others throughout my career, I have developed several core principles, each of which guides my teaching philosophy.

Learning is an active enterprise, and the communication of new concepts is only effective when both the teacher and the student maintain an active interest in the material and the process of understanding it. This first principle reminds me that, as a teacher, my role begins with introducing new material in such a way that students can activate their interest in the material and make it their own. This can be a very challenging aspect of teaching physics. Motivating the study of science concepts requires overcoming many alternative conceptions, not only about the science, but also about the scientific process and scientists themselves. It isn't a singular goal, but making physics cool is essential to initiating active student interest.

How will I make science cool? Drawing from my background as a teacher, researcher, and student, I bring a broad range of experiences and interests to the classroom, which gives me the necessary flexibility to connect a new concept to a student's knowledge base and personal interests. For example, to connect physics to everyday experiences, I describe how LCD screens use polarization and color-mixing to display images, or how the iPhone works by sensing changes in capacitance. Making a clear connection between technological breakthroughs and fundamental physics research gives students a better understanding of the scientific process. Bringing current research into the classroom, and bringing students into the lab are both effective ways to show students how current research, and physicists specifically, fit in to global scientific progress. When students realize the impact they can have on their world by knowing how it works, they tend to be much more interested in continuing to learn about it.

I enjoy the fact that a student's perspective can be different from the teacher's perspective in surprising and interesting ways. I think of this second principle as *teaching in the other direction*, in that I often have as much to learn from my students as they have to learn from me. Students teach me, as an attentive instructor, how best to instruct them. By being open to this aspect of the educational process, I can adapt my instructional style to reach as many students as possible. In the classroom, I demonstrate to the students that I am committed to their learning experience by creating opportunities for feedback and responding quickly to such feedback.

One example of this feedback-based approach that I am interested in exploring is the use of "muddy cards." Blank index cards are distributed to each student at the end of a class or lab session, and students are asked to write down the muddiest topic of that session, the most difficult concept they are struggling with, or simply something they liked or did not like about that session. The cards are anonymous and used by the instructor to clarify aspects of the material that were not originally clear. Muddy cards have been used successfully in a wide range of courses, and students surveyed in a study conducted at MIT responded positively to the use of muddy cards, especially when the clarifications are posted to a course web page or online forum [1]. This is an example of how instructional technology can be used to quickly clarify the muddy points without dedicating in-class time.

In class, I strive to create an environment where all questions are asked, and students feel comfortable coming to me for assistance. To accomplish this, I make it a point to maintain an appropriate level of informality that puts students at ease and demonstrates that my goal is to learn physics *with* them, and facilitate their learning in general. To maintain this environment, it is also important to foster interactions between the students that support these goals. Group discussions, collaboration on lab projects, and group problem-solving exercises all provide opportunities for positive interactions.

There are many settings in which to learn physics, and I feel they each serve students in different ways. It has become clear through research in physics education that a course based solely on lectures does not create an active learning environment, regardless of the skill of the lecturer. Whenever possible, including demonstrations, hands-on laboratory work, and group collaboration gives students the opportunity to engage the material directly. One example is the use of expert groups, where each member of a group becomes an expert on a sub-section of the material and then teaches that section to the rest of the group. The laboratory component of a physics course also provides opportunities for group work, and provides a focus on physical phenomena rather than on abstract descriptions. By remaining grounded in phenomena, students are able to connect new concepts to their established knowledge frameworks.

In addition to helping students understand physical phenomena, one of the most important skills I can teach is the ability to interpret and solve new problems through scientific reasoning and analytic descriptions. This process has historically been taught by brute force: assigning students to solve as many different problems as possible and check their answers against known solutions. My approach is to demonstrate the expert perspective with careful attention to explaining the assumptions, approximations, and reasoning that are typically not described as explicit steps in the problem-solving process. The goal is to help students discover that there is more to solving physics problems than choosing an equation and plugging in numbers. One specific way I achieve this is to include a balance of quantitative and qualitative questions for students to answer.

Teaching Experience

As a senior undergraduate at Whitman College, I served as a teaching assistant for the introductory laboratory course that was taught in the studio physics style. Students were guided through the discovery process using worksheets and PASCO scientific data-collection equipment. As a graduate student at Duke, I led laboratory sessions for introductory physics courses designed for Engineering and Pre-Med students. These courses also used PASCO equipment, and followed a similar Socratic approach. I found this format worked well as long as the weekly lecture, recitation sessions, and laboratory activity were well coordinated. Students were not always prepared for the material they covered in the lab session, which lowered the effectiveness of that experience. The *just-in-time teaching* technique suggests short pre-class or pre-lab assignments to encourage preparation, an approach I am now inclined to use in this type of course. These pre-class activities are another example of how online resources can be integrated into the classroom.

After becoming a research assistant, I chose to continue my role as a teacher and mentor by tutoring physics students through the Duke University Peer Tutoring Program. Through one-on-one tutoring, I discovered the importance of quickly identifying a student's preconceptions of the material, especially any preconceptions that are preventing them from correctly formulating their problem solving approach. I found one effective technique was to take a few minutes early in a session to discuss the material from their lecture and demonstration sessions. This gave me an opportunity to reiterate the new concepts and the ways in which common alternative conceptions are incorrect.

This spring I will be co-teaching a Research Skills course that is designed to expose students to many of the tools used in a research setting such as the LabVIEW programming language, data analysis, optical system design, numerical modeling and document preparation. The process of designing a new course has been very enlightening. I have worked carefully to strike a balance between interesting and exciting activities that can be completed by novice students given limited time and hardware resources. My co-instructor and I have collaborated to design a five-week section of the course in which students are introduced to LabVIEW and the ROOT data analysis package. During the five weeks they will design, program, and conduct an experiment using one of several Vernier LabPro data-acquisition sensors. Next they will collect energy spectrum data via LabVIEW software that digitizes a Germanium detector signal, and finally they will analyze their data using the ROOT data analysis software.

Outside of the university setting, I have contributed to an elementary school outreach program by designing and presenting a variety of science activities to 2nd, 3rd and 5th grade classes. Of my various teaching experiences, outreach activities have been some of the most challenging. They require advance concepts to be distilled to their fundamental components and then presented in terms that are familiar to students with little or no experience with abstract physics concepts. Fortunately, I find it as rewarding as it is challenging and plan to maintain outreach as a component of my long-term career. I found that many students are simply lacking a science authority in their educational experience, and could greatly benefit from an occasional expert classroom visitor. Encouraging curiosity about science at the elementary school level is one of the most effective ways I can help improve the quality of students throughout the educational system.

Teaching Interests

In addition to teaching calculus- and algebra-based introductory physics, optics, mechanics, and traditional upper-division courses, I am prepared to teach and develop courses for advanced physics majors as well as for non-majors. For example, as a musician, I would be interested in teaching the physics of acoustics, sound and music. I am also excited about the possibility of developing courses related to my own field of Atomic, Molecular, and Optical physics. A seminar-style introductory class could review recent research topics and historical perspectives for incoming undergraduates or an advanced course could have a laboratory component that utilizes much of the equipment I would develop for my research.

References

[1] S. Hall, I. Waitz, D. Brodeur, D. Soderholm, and R. Nasr, Adoption of active learning in a lecture-based engineering class, *Proceedings of the 32nd ASEE/IEEE Frontiers in Education Conference* **1**, T2A_9 (2002).