The beginning of every semester is an exciting and intense time for faculty with new students, texts, ideas and often a brand new class. In common with other faculty, I spend a lot of time before the semester begins going over the details of the class - the text(s), notes, the development of meaningful concept questions, highlighting the common stumbling blocks and developing worksheets and activities to refresh student's understanding of the math and physics prerequisites. This is performed with two major goals in mind - students at every level should leave at the end of the semester with both wider *knowledge* of the subject and a larger toolkit of *skills*. Although the depth and scope, as well as the required mathematical sophistication, vary greatly between upper and lower level classes, these goals propel the direction of the classes I teach. However, often, in doing this, I can forget why I decided to study Physics. To remind me, I keep an 8-year-old thank you note from a former student prominently displayed where I can see it. One sentence in particular keeps me on track: "You made Physics sound as beautiful as music." And Physics is beautiful, for it is driven by the idea that a few fundamental principles work to explain an outwardly complex physical world. Certainly skills and knowledge are imperative, but conveying the excitement and beauty of the topic goes a long way towards mitigating the (perhaps undeserved) reputation of Physics as "difficult" or, even worse, "dull."

The specific skills taught within a class must include the ability to use one's knowledge to tackle problems analytically and to follow a logical train of thought. Although the knowledge set is fairly well defined in the traditional Physics sequence, tackling problems is a skill that needs to be learnt. Students are convinced that they understood perfectly what they read or heard in class and still are paralyzed when it comes to attacking a problem. There are several strategies for overcoming this, which include practice, in-class discussions, and in-depth in-class conceptual questions (see below). In a wider context, the development of these skills is valuable in the analysis of a range of situations - a quick numeracy, the ability to link cause and effect, to have a built-in reality detector, to push students to a level of scientific literacy, which is as important to today's citizens as the traditional definition of literacy. I often tell students "Every educated person needs to know....." with examples ranging from the knowledge that the speed of light is finite and sets an ultimate speed for information transmission, to how light from distant astronomical objects is transmitted across the Universe (no, it is not magic), to the idea that our intuition serves us poorly at either extreme of length scales. Hence even in the large service courses, Physics 211 and Physics 212, I have introduced ideas from upper level classes. In discussing Newtonian Mechanics, I give them a small taste of Special Relativity - pointing out that we are making assumptions about time that common sense dictates are perfectly acceptable and that Einstein worried about.

Pedagogical Approaches

Even before my first year as a tenure track faculty member, I had begun the process of moving away from the traditional lecture/homework/test format. Our department has always been an early adopter of evidence-based pedagogical strategies and was the first at UNL to employ clickers, a method that allows for students to respond anonymously to in-class questions with the click of a remote device, leading to much greater in-class participation [1]. Several studies have shown the efficacy of active engagement in the classroom [2] and the AAPT (American Association of Physics Teachers) workshop I attended during my first year as a tenure track faculty member drove this point home. With a wide range of strategies to choose from [1,3,4], some skepticism of the latest fads is in order, but the overwhelming statistical evidence [2] points to significant improvements in both long-term retention and problem solving skills when student-centered, discussion-oriented approaches are used. This approach used to make students very uncomfortable, with comments along the lines of "I like to write down everything you say and *then* go home and review it" or "I am uncomfortable discussing my understanding (or lack thereof) with my neighbor" or "I don't like thinking so hard in class"(!). Over the long arc of my teaching career, I have noticed that much of this discomfort has faded away. Certainly, students are now more accustomed to these "new-fangled" teaching methods, but in addition, I motivate them by showing them the data on student test scores and long-term retention, repeating it from time to time during the semester. I also point out that this method is more fun - rather than listen to me drone on and on, they will be encouraged to talk to each other about the questions under discussion, even to get up and walk around when appropriate. Most importantly, I took to heart a comment a student made on her/his teaching evaluation. She/he identified as a secondary education major and said that the most important thing she/he took from the course was the comfortable and welcoming atmosphere in the classroom, making it a place where questions and comments were welcomed. I had not consciously tried to do that before, but after this statement I make it a priority. I make at least one positive observation on every question a student asks in class, pointing out that this question confuses a lot of students or that this is a topic worthy of repetition and make sure the student knows I am taking it seriously. Sometimes, I write a set of concept questions on that topic to start the next class. I had a student who asked plenty of questions and came to my office often. After he was comfortable with me, he said, "I must be the dumbest kid in class since I ask so many questions!" I pointed out that since he sat in the front row, he didn't see the nodding heads or the looks of relief on the students who sat behind him - they were all confused but didn't want to speak up. In short I try to make the classroom environment one that allows confusion and misconceptions to be aired without self-consciousness. Experience has allowed me to become a more relaxed teacher, to enjoy students' enthusiasm and questions and energy.

My approach (based on [1]) is to start with a short (<10 minutes) lecture that covers the main points, followed by concept questions and class discussions. For these short periods of lecturing, I try to remember that lectures are performance art and to let *my* enthusiasm shine through, telling them a Physics story, using modulation and pauses to build excitement. For example, I might say (accompanied by the relevant slides so they can process the information in at least two ways) "OK let's assume that the speed of light *is* constant, that it doesn't change with your frame of reference, that it is the ultimate rate at which we obtain information, what would that mean for how we measure time (or length)?" Pause....drumroll if possible...let confusion abound...let them think about their assumptions and then put up a possible answer. Hand out pretend stopwatches (or larger than life "meter" sticks). Ask A to run across the classroom while B stands still. Ask the class to think about what A or B sees as the time. Even if they don't share your enthusiasm (yet!!), it makes them laugh (or roll their eyes) to know *you* love it so much! This approach took me a while to develop, because I needed the confidence one gains from repeated teaching to allow myself to open up. This is not to say that there are not still lectures that go over about as well as a lead brick, or that there are not days when everything drags, but there are far fewer of them.

There is an enormous bank of carefully tested concept questions [5] available for the first two semesters of general physics, Mechanics, Waves & Thermodynamics (Physics 211) and Electromagnetism & Optics (Physics 212). For upper level classes, there is a dearth of readily available, well-tested concept questions [6], which are helpful to students' understanding and which are at the right level (neither too advanced or too simplistic). The development of concept questions must be done in a classroom setting and can take more than one semester of teaching the same course. I have developed numerous concept questions and activities (see Concept Questions in teaching folder), for Physics 213 (Modern Physics) and Physics 461 (Quantum Mechanics), weeding out the unnecessary, unhelpful and/or repetitive ones and developing new ones as I notice conceptual difficulties.

Not every conceptual difficulty is suitable for in-class clicker questions, but they play a significant role in revealing student misconceptions. For example, while teaching basic Quantum Mechanics in Physics 213, I noticed that the biggest obstacle was not that students were puzzled by the concept of a wave describing a particle, but rather that they did not really know how waves behaved. Waves *are* covered in the prerequisites for this class, but using what they have learned in another context is often confusing. Hence I developed a series of short questions on wave mechanics, put wave worksheets on Blackboard, slipped in surprise questions on waves and let them know in every way possible that they were responsible for relearning the material and that they had the tools to do so.

The upper level electromagnetic theory courses, Physics 451 and Physics 452 were among the most successful classes I taught, as judged both by student evaluations (receiving a perfect student evaluation *average* of 1.0 in Physics 452) and by emails from former students who had gone on to very competitive graduate schools, telling me how well prepared they were for graduate level Electricity and Magnetism. The two main stumbling blocks I identified in these classes were (i) the concept of symmetry and (ii) the application of and fluency in vector calculus (a prerequisite for the class). Although I developed a few concept questions around these ideas, I found that a more successful approach was to make sure they articulated both these points in every problem they did. I created completely new homework sets, with questions that required them to make a sketch, describe in a paragraph the symmetry of every problem and the resulting assumptions they could make based on this symmetry. In addition, they had to detail in words, which vector operation they would use, the coordinate system they would use, how they would do it and justify why. The idea was to make this kind of thinking second nature, reinforced by asking them similar questions for every problem on every exam.

The homework was difficult and time-consuming (for all of us!), but several students have commented on how much they missed them and wish I would do something similar for Quantum Mechanics 461. (I'm working on it...)

I also work numerous problems in class, often with concept questions embedded in them. The point of doing this is not to show them the details of any particular problem but the methods used to solve it. What is being asked and how can we approach it? Are there multiple methods one can use and which is fastest/easiest/ cleanest? Why is one approach just completely incorrect?

Asynchronous Distance Learning

Brian Robertson and I developed a distance-learning module on nuclear radiation. The development of this course was funded by the Nuclear Regulatory Commission and involved three schools, UNL, Kansas State and Baylor University. UNL developed the module on forms and sources of radiation and the interaction of radiation with matter, with Brian and I dividing the work between us. The format of the class consisted of Powerpoint slides, interspersed with hand written problems solved on a tablet and synchronized with voice. The lectures were taped using Camtasia Studio and were uploaded to a Blackboard course website. Student had a variety of options for downloading the slides and notes as well as for listening to the lecture. (See syllabus) Homework and tests were also delivered via Blackboard and the tests were locally proctored at all three institutions.

Student Mentoring

In addition to teaching, I have mentored several graduate, undergraduate and high school students. Every graduate student has successfully navigated the post Ph.D. job market, working in precisely the positions they desired. Dr. Andrew Baruth wanted to remain in Nebraska because of strong family ties, and to teach at a small undergraduate institution; he is now a tenure-track faculty member at Creighton University. Dr. Ellen Day wanted to work in Medical Physics and is now a Senior Medical Physicist in the Alleghany Health Network. Dr. Abhijit Mardana wanted to remain in the US and find a job in industry; he is now working at Intel. Dr. Nina Hong also wanted an industry job, preferably in Lincoln where her husband had a very good job; she is now working at JA Woollam and Company. My very first graduate student, Dr. Zhongyuan Zhao, had always set his sights on a faculty position in China, and is a very successful faculty member at Yongshan University.

Numerous undergraduate students who worked with me have received UCARE awards for varying durations, and have flourished, publishing papers at UNL, and then going on to very prestigious graduate schools. Sam Davis went to Northwestern University, Dan Williams to the Optics program at the University of Rochester and John Mullins to the Mayo Clinic Biophysics program. Celeste Labedz, who worked with me starting the summer before her freshman year, and who will graduate in May 2016, is almost certain to continue this successful trend. She is coauthor on two papers and the winner of two Physics Department awards: the undergraduate award for Excellence in

Research and the Roger & Suzanne Kirby Outstanding Physics Major award. This is only a small subset of the awards she has won, including a Regent's Scholarship and the outstanding undergraduate award from the Department of Earth & Atmospheric Sciences. She is a double major in Physics and Geoscience and is applying to graduate schools for a Ph.D. in Geophysics. Having completed an REU in Seismology at MIT last summer (2014), she has found her calling - Seismology, something I know very little about! I was honored when she invited me as her nominee to the People Who Inspire Banquet held this fall by the UNL Chapter of Mortar Board. Among the 28 Mortar Board members at this banquet, I was the only faculty member nominated (the rest were relatives, religious mentors, sorority advisors) and I was very touched to listen to her speech that described why she had chosen me - definitely a highlight of my year!

In addition I have worked with several summer undergraduate students and high school teachers in NSF funded REU (Research Experience for Undergraduates) and RET (Research Experience for Teachers) programs. Two REU students, Ellen Day and Keith Foreman, came back to work with me for their Ph.Ds. Mr. Mark Shearer, the Physics teacher at Lincoln Southwest High School, has worked with me for three summers and is a coauthor on two journal articles. Several high school students have worked with me during the summer, with partial funding from the John Woollam Foundation and have performed extremely well. The most recent high school student, James Rehnwalt Alexander (summer 2015), collected enough data to form the nucleus of a publication and is also a National Merit Finalist.

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