My Teaching: Philosophy and Practice

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Background

I was hired by Adelphi 13 years ago with very little teaching experience: I had been a teaching assistant for two semesters in graduate school during which I led discussion sections, but had never prepared a syllabus or an exam or given a formal lecture in a class. The department must have hired me despite this lack of experience, perhaps on the strength of the enthusiasm with which I presented my research seminar. When I walked into a classroom for the first time as a faculty member at the end of August 1995, I was unprepared for and oblivious of the immense challenge it would be to become a good teacher. However, I like to think that I had some qualities that gave me potential: passion for my subject and the desire to share that passion with others, natural empathy for my students, and, from giving research seminars, considerable practice in organizing and explaining complex topics. Without any formal training in teaching but with a scientist's preference for empirically tested approaches over philosophical visions, I developed my teaching style largely based on what I and others found effective. Thus, I will describe in this essay not just my teaching philosophy, but my teaching practice.

Goals and Commitment

My primary goals as a teacher are to challenge the students to think and engage with the subject and to give them the tools to approach science independently and with insight and analytical rigor. To achieve these goals, I commit myself whole-heartedly to my students, using a variety of tools and techniques to explain and to persuade them to work so they will understand and gain intellectual satisfaction for themselves. I am also committed to a constant effort to improve my teaching.

My Development as a Teacher

I started out teaching as I had been taught. During my first few years, I was simply trying to master the material with the breadth and depth necessary to teach it, and present it to the students in a clear and organized way. I taught nine different courses (counting labs separately) during this time, including a seminar on "genetics & society" for freshman and for Honors College non-majors, two undergraduate major courses with lecture and lab, one seminar for senior biology majors, two masters-level lecture-and-discussion courses, and one masters lab course. For all of these courses I developed most or all of the content myself. I believe that during this time I became an effective lecturer and discussion leader.

Aspects of my teaching practice that I developed during this time include the following: In lecture, I emphasize the key concepts in each area and reduced the extraneous details that would only overwhelm the students; I try to explain, when possible, the experimental basis of our knowledge, to help students see science as a process and not a collection of facts; I illustrate my lectures with figures and photos and even short animations; and, most important, I involve the students in the classes by pausing frequently to ask them questions, so they will think about the information and not just passively write it down to memorize later. Knowing that some students learn best through hearing, some through reading, and some through images, I try to convey the information in as many different ways as possible. In the graduate courses I worked hard to train the students in how to read scientific papers, one of the most challenging skills that a scientist must acquire. In all the courses I encourage the students to master the material through their own efforts. Towards this end, I assign problem sets, I make old exams available with additional problems and questions, and I distribute preparation sheets for each exam at the start of each new section so students can prepare at their own pace. In the graduate courses, I assigned students to explain particular experiments to the class during our discussions of articles. In my tests and lectures I try to emphasize problem solving and use of the information. Biology courses are notoriously "content-heavy", but I also want the students to be able to think about what they have learned. Asking "thought" questions in class and putting such questions on tests encourages students to view the subject as one where reasoning and insight, and not just memorization, are important. Finally, I work hard to help the students, and their recognition of my work ethic motivates them to work hard also. I grade and return exams (always essays and problems, never multiple choice) by the next class, and try to give the students timely feedback on other assignments as well. I make my expectations clear by giving the students the rubrics I use to grade essays, presentations, and lab reports. I make myself accessible to students even outside of office hours, try never to be too busy to see a student, and always offer extra review sessions before exams. My main criterion for deciding on an assignment is whether it will be help the students learn, not how much work it will be to grade.

Expanding My Teaching Approaches

Once my flurry of new course development had abated, and I was able to concentrate on updating courses each year rather than preparing new ones from scratch, I began to change how I taught, introducing innovations designed to give responsibility for learning to the students. I received some exposure to "inquiry based learning" and other educational ideas as chair of the Senate Committee on Teaching & Advisement, which my colleague and friend Patrick Kelly persuaded me to assume in fall 1998 (I co-chaired this committee with him for the first two years, then acted as sole chair through spring 2006 except for a sabbatical year in 2002-03). Although it was a lot of work to be the lead organizer of and director of publicity for several teaching workshops and brown-bag lunches every semester, I learned a great deal from the events myself, and enjoyed providing opportunities for all faculty to become better and more reflective teachers. I will first discuss how inquiry-based learning has become the guiding principle in the genetics lab class that I have taught most often.

Inquiry-Based Learning in Genetics Project Lab

My early lab classes mainly consisted of a series of standard exercises, most lasting only one or two weeks and exposing the students to a variety of common techniques in the area. I gradually realized that this approach was unsatisfactory, as the students usually did not understand why they were carrying out an experiment and certainly did not master the techniques (how could they, in a single trial?), nor did they retain for very long what they had learned. I contrasted these outcomes with what I saw among the undergraduates who carried out research with me for two semesters: much better understanding of their projects and definite mastery of techniques. Why not try to give all the students in my genetics lab class (the lab that I have taught most often and most recently) an experience more like that of my research students? One problem was a lack of the necessary equipment: to be able to work as intensively as my research students, we would need thousands of dollars of equipment that we did not have. I applied for and was awarded a small grant ($19,000), matched by Adelphi, from the National Science Foundation Division of Undergraduate Education to buy the equipment to be able to run the genetics lab in a project lab format.

After two trial years running the genetics lab in the new format but under the old number, I realized that I had actually created a new course and put through a proposal that was approved for Biology 224, Genetics Project Lab, a 2 credit course. This course is now required for all biology majors. The project lab meets twice a week, for 2-1/2 hours each time (I discovered during the trial period that this double-the-normal-time was necessary for the students to become truly immersed in the lab). During the semester the students carry out two related projects in genetics, both involving the characterization of plants with genetic mutations that were identified as part of research in my lab. In the beginning of the semester the students are guided step-by-step by me, the teaching assistant, and a detailed lab manual through preliminary experiments that teach them basic techniques for studying the plant we work on, *Arabidopsis thaliana* (a small relative of mustard and broccoli that is the most widely-studied plant in the world because of its favorable properties for laboratory research). They learn how to sterilize the seeds, grow and analyze the seedlings, isolate plant DNA, and analyze the DNA by polymerase chain reaction (PCR) and electrophoresis. About midway through the semester the students are given much more freedom. In one of the projects, trying to map the genetic mutation in "their" plants, the students work together in teams to test different chromosomal regions for the presence of the mutation. They perform essentially the same techniques multiple times during the semester, mastering them to the point where they carry them out on their own without instruction. In the other project, the students must plan their own experiment to characterize the growth and development of the mutant. They research the scientific literature to identify what types of experiments scientists studying similar mutants have previously carried out, discuss with me to get advice on feasibility, and then present their planned experiment to the class about the midpoint of the semester. After this point, some students choose to work on their projects mainly outside the scheduled lab periods, while others use the scheduled lab time exclusively. I am available for guidance and questions throughout, but enjoy watching the students come into lab and immediately go to work as if they knew exactly what they were doing—which, in most cases, they do. With up to 12 different projects going at a time for each of two sections, this approach is very demanding on the instructors, the TAs, and my lab technician, but it is worthwhile. At the end of the semester the students present the results of their characterization experiment in a poster session, held in the basement corridor outside my lab with refreshments. Students first give practice presentations to each others, and then present to me. I invite my colleagues to come also to see the results of the students' efforts. The project lab thus gives the students a chance to discover how research is carried out and what the rewards and frustrations are. For some this is enough of a taste to know they never want to do research again, whereas others are hooked and begin doing research with me or one of my colleagues. In general the feedback from the students has been very positive, as they have commented that they really get a sense of what research is about and that they enjoy mastering a few techniques (of course, many of them also express frustration that the experiments do not work every time, but I try to encourage them with the idea that in "real science" experiments do not always work either).

Integration of Research and Teaching

A brief digression on my integration of research and teaching: I initially viewed research and teaching as two very separate parts of my job, but over time I have brought them together in a way that has strengthened both. My teaching, especially of my lab classes, has benefited as I have worked to increase the independence and investigative activities of the students to more closely parallel what my research students do. My research has benefited in several practical ways as well: 1. As I improve the lab course year after year, the students' results are able to contribute to the actual progress of our projects; 2. Every year a few students who have taken the genetics project lab course decide to continue research in my lab; these students are often quite productive as they have a solid background in the theory and techniques of the ongoing projects in my lab. 3. I am sure that the integration of my research and teaching has strengthened my grant proposals to the National Science Foundation and contributed to my ability to continue to get funding.

Applications to Lecture and Seminar Classes

I began using student-centered learning approaches in my lecture and seminar classes as well. For example, in my senior-level molecular cell biology II class I use skits to help the students put together the many details of a process we had studied. In this class we focus on just two or three topics in an entire semester; each topic might be described in only a page or two in a cell biology textbook, but because we read the original scientific articles on which the textbook is based, we go much more into depth, scrutinize the evidence, and analyze the approaches. To ensure that the students were able to see how all the details fit together at the end of each unit, I assign the students the roles of the different proteins and other molecules that are involved in a process. Each student "wears" a large sign giving his or her identity and then the entire class (this is always a small class) performs the process. Initially I told each student what to do, but I now give the students more responsibility for discussing with their fellow cast members and planning the skit. I have begun to incorporate this approach into my large genetics lecture class (47 students in fall 2007) by breaking the class up into small groups, giving them time to plan, and then asking one or two of the groups to perform for the class while the rest of the class observes and, if necessary, corrects. We have practiced dividing a cell's chromosomes in mitosis and meiosis and regulating expression of cellular genes in response to different nutrient conditions. I try to time these exercises so as to provide an optimum break in the middle of a lecture.

Other Features of My Teaching Approach

Three additional features of my teaching are an emphasis on teaching skills and not just facts, on using technology appropriately to enhance learning, and on continuous improvement.

Teaching of Skills

Initially I felt, as a biology faculty member, that my emphasis should be on helping my students master the area of biology that I taught, which I assessed almost entirely through their performance on exams. Three factors have led me to broaden my emphasis to educating my students in general skills including reading, writing, problem-solving, and data analysis. First was my observation (not a novel one by any means) that students retain and build on these general skills, but easily forget facts that they learn for an exam and never use again. Second, my contact with my senior colleagues and master teachers Jerry Churchill and George Russell showed me that incorporating teaching of these general skills into courses can enrich, not detract from, student learning. Finally, when I compared our departmental learning goals (that I helped to formulate!), including the ability to read scientific articles, design and analyze experiments, and communicate about science orally and in writing, with what I taught in my classes, I realized that my students were not getting enough practice in these skills despite their importance for our students' success in their careers. Problems with science students' reading and writing seem to be widespread; not only do my colleagues also lament their students' writing skills, but I have read that across the country, science majors tend to write worse when they graduate from college than when they entered, and our students who take the MCAT have the most difficulty with the reading passages. I am beginning to address this problem in my genetics class by assigning more reading and more writing. Students must now read two recent articles relating to genetics from *Scientific American* or *Natural History* magazines, and write a summary-and-reaction essay on each. To give students practice in working on their writing, I allow them to revise and resubmit their essays as many times as they want (surprisingly few of them take full advantage of this option!). Many students comment how rewarding it is to read these articles, which they might previously have found incomprehensible, and to see that what they have learned in the class enables them to understand most or all of the contents. This past year I also adopted George Russell's practice when he taught genetics of having the students read James Watson's *The Double Helix* and summarize it; students also found this very worthwhile and highly relevant to the class. While these small steps might seem minimal to colleagues in the humanities, I believe that these assignments are considerably more reading (outside a textbook) and writing than is found in most science classes. I am now proselytizing among my biology colleagues to give their students more reading and writing assignments as well.

Use of Technology

I have incorporated use of technology into my classes extensively where I think that it can help the students; this includes Powerpoint, Blackboard, Moodle, podcasting, and WarmUp questions. I have sat through too many dull slide and Powerpoint presentations at scientific seminars and conferences to think that Powerpoint is a magical tool—except, when used improperly, as a soporific. However, it has its place as an efficient way to present images and animations that can enliven a lecture. I actually tend to write much of my key points on whatever kind of board (white- or chalk-) is available in my classroom. I was an early adopter of Blackboard, which I used enthusiastically because it enables me to give the students many resources easily. I include in my Supplementary Materials most of what I posted on Blackboard for the most recent edition (fall 2007) of Biology 222, Genetics. I post links to useful Web sites, my lecture notes, answers to problem sets, and extensive sets of old exams and old exam answers. Initially I was reluctant to post old exams, but I realized that my fears were misplaced. Did I fear that the students, through studying old exams, would learn all the material so well that they would all get 100's on the tests? The readers will not be surprised to learn that this has never happened. Did I fear that I would have to make up new tests each time I taught the class? I view this effort as a small price to pay to help ensure that my students are well-prepared. Blackboard has also been very practical for carrying out course feedback surveys and posting every document that I give to the students so that students who miss a class can get the information they missed instantly and without troubling me to print out or find in my files an extra copy. This semester I am using Moodle instead of Blackboard for the first time, initially with the same approach, but as I gain familiarity with Moodle I hope to use more of its advanced features to foster discussion. Most recently (the last two years) I have begun "podcasting" my lectures, i.e. recording them on digital voice recorders and then (through the FCPE) posting the recordings. Enough students say that they find this useful that I have continued the effort. This past fall I even went so far (too far, probably) as to edit the lecture recordings to remove the long silences while I was writing on the board or getting an answer from the students (only the lecturer's voice, unfortunately, records well). I have not noticed any effect on attendance from posting either my lecture notes or lecture recordings.

Blackboard also gave me a way to encourage students to come to class prepared, having read the background information in the textbook, which I believe will help them understand and retain more from my classes. Despite carefully listing on my syllabus which pages in the textbook are appropriate, few students seemed to be making this effort. I read about and implemented in my genetics class the use of "WarmUp questions", part of an approach called "Just-in-Time-Teaching" (http://134.68.135.1/jitt/) that was developed with NSF funding. Before each class I post on Blackboard a question that covers an essential topic to be discussed in class. Students must submit their answers several hours before class. Students are given full credit for any reasonable answer. Ideally I have time to look at enough of the answers to see if there are common misconceptions which I can then address in my lecture. The feedback I got from students indicated that they recognize that the WarmUp questions do indeed increase their comprehension. However, students in past semesters also complained that having to do a WarmUp before every class was too much work. In my most recent semester of genetics, therefore, I made the WarmUp question optional. As a result, few students did the WarmUp. At the end of this semester, some students indicated that they wished the WarmUp had been required so that they would have been forced to do it for their own good. I will probably fine-tune this approach in the future—perhaps requiring it every other class. My goal is not to satisfy everyone, which is clearly impossible, but to find that optimum balance of demands imposed by me for the students' own good and students' flexibility to work and learn at their own pace.

Striving to Improve

I hope I have demonstrated what I feel is one of my strengths as a teacher: an openness to new ideas and to criticism, and a desire to improve continuously. I incorporate new ideas that I learn about through readings and workshops and use the evidence I gather from my own impressions and from the formal "course improvement" surveys that I conduct at the end of each class to modify my courses each time I teach them. I have never taught the same course exactly the same way, as I'm always striving for that perfection where every student, not just the strongest, is enthusiastic about the material and does well in the course.

Conclusion

I view teaching as a pleasure and a privilege. Much as I love research, I would have to say that I find teaching even more rewarding. I love sharing my enthusiasm for biology with my students and trying to create in them the same excitement about the wonders of life. I love seeing the light in a student's eyes when he or she understands a difficult point or solves a challenging problem. I am committed to my students' learning—a commitment which shows in the time, thought, and effort I put into my teaching.