

Statement of Teaching Philosophy

For the past few years, I have been teaching biomedical researchers and a handful of high-school students about computational modeling in cell biology. As a physicist immersed in a biomedical research center, developing collaborations aligned with my interests required teaching my colleagues about nonlinear dynamics and its application to cellular regulation. In addition to countless informal discussions, the effort included a 14-hour lecture series attended by senior investigators and postdoctoral fellows. Through this, I learned to apply a key rule: Teach the "why" first, the "how" last, and take time to expose how *this particular* audience can benefit from understanding the "how". I also noticed that clarifying my own motivations is critical for maintaining perspective on why I choose to teach. Involving high school students in research, for example, is motivated by my belief in the value of learning to continuously evaluate and refine one's own understanding. By teaching them physics, mathematics, cell biology and computer modeling through research, I can offer an environment in which critical evaluation and refinement of their thinking is an explicit *goal*. They are not supposed to know some prior answer, as they often are in school. I strive to support my students enough to make progress, but little enough to call this progress their own. This process reveals to them the value, joy and reward of working through a problem with increasing precision, and gaining new insight. My role is to spark their curiosity and pass on my sense of wonder, but also help them build strength and confidence that carries them past their difficulties. My most rewarding experience was mentoring a talented high-school student, Mary Cerulli, in modeling angiogenic pattern formation. Mary worked with me for two years, reading and synthesizing information, then helping me build the model. Through repeated back and forth between model and literature, she developed a solid understanding of the meaning of a model's state space, attractors, dynamics, and network representations used to visualize them. She intends to pursue theoretical research in biology as an undergraduate at University of Pennsylvania. Encouraged, I went on to lead a team of four Boston University Academy students in writing code for regulatory dynamics simulation.

Based on my experience, I believe that providing a setting in which students continuously revise their understanding is central to effective teaching. While research mentoring is a natural fit, my goal is to structure lectures and problem solving seminars around it as well. In the lecture hall, the first step is to present a simple, hierarchically structured, top-down view of a topic. This step needs to provide critical information, but also kindle the motivation to understand it. The next step is to start teaching the "how": highlight different ways in which key principles translate to concrete applications. This could be done passively, via interesting or counterintuitive examples. The problem with a passive approach is that it does not reach most students. Moreover, it does not unearth a student's particular misconceptions. Although I did not have the opportunity to put it into effect, methods of Peer Instruction were shown to alleviate these problems (Crouch & Mazur, *Am J Phys* 69:970, 2001). To implement it, I will break up each lecture into 4-5 discrete units. In each unit, I will briefly present a concept, along with 1-2 very brief but concrete examples of how it is applied (goal: information & motivation). I will then pose a conceptual multiple choice question, ask students to record their answers, then find a neighbor who disagrees. I will let them debate their reasoning for a few minutes, then record their revised answer (using clicker technology or show of hands). This process encourages students to locally

"debug" their logic and work through specific misconceptions. For those who got it right, explaining it to their peers can deepen their understanding or bring up lurking inconsistencies. To conclude the unit, I will explicitly highlight common misconceptions behind wrong answers, trace their roots to everyday experience and point to situations where they clearly fail. Mastery of this aspect of my lectures will require years of careful attention to wrong answers. As a concrete step, I will keep cumulative records of misconceptions that I encounter as I teach. I expect this data to improve my effectiveness in selecting questions that expose them. Lastly, if a question proves to be relatively easy, a harder, counterintuitive one on the same topic will follow.

The above approach focuses on understanding key concepts. Developing quantitative problem solving skills requires a different structure. In my experience, students benefit from alternating between working on problems alone, in small groups, and guided at the board. Currently, my preferred problem solving seminar structure has three tracks: 1) a challenge problem posted on the board, which students may attempt individually for extra points; 2) division of the class into groups of 3-4 to solve a subset of homework that covers all problem types; and 3) two of these groups working at the board on problems they have trouble with, guided by my questions. In addition to specific course material, my goal is to teach students the value of mistakes. I aspire to show that each question that exposes a misunderstanding, each incorrect answer in class is an opportunity to find a hidden misconception. This sidesteps the notion that being wrong is a result of not being smart. It leverages the fact that science itself is built on a set of assumptions, to which we bring a considerable set of our own. We distilled these from personal, naturally incomplete experience with the physical world. This view of misconceptions guides the conversation towards the edge of students' comfort zone, fostering healthy resilience towards being challenged. When practiced with attention and respect, I believe this approach can deepen understanding, while fostering patience, ambition and determination. As a concrete strategy, I will encourage students struggling with particular problems to work through them at the board.

Students can expect me to regularly evaluate the effectiveness of my methods, in no small part by listening to them. I will encourage them to provide critical feedback, and look for advice from experienced teachers. My evaluations on the Physics 101 Interactive Learning Seminar at Northeastern University were consistently positive. I scored high on clear communication of ideas, feedback to students, respect, effective action when students did not understand the material, availability outside class and level of enthusiasm. I did notice, however, that working on homework in small groups did not benefit all my students. Some require more structure, other benefit from more work alone, and a few students rarely engage without an explicit challenge. The three seminar tracks I described above are in response to these observations.

One of my long-term goals is to help diminish the barriers of inter-disciplinary communication by teaching about key concepts in one discipline advancing another. Moreover, I find tremendous value in showing students that their critical thinking skills can encompass the often-dreaded subject of physics. Consequently, I am especially interested in teaching physics, network science and computational modeling to both physics and non-physics majors, particularly biology students. I would also welcome an opportunity to develop a systems biology course for physics students that does not presuppose basic cell biology knowledge, or an interdisciplinary graduate course on modeling biological regulation.