Teaching Statement

Daniel Forger

Effective teaching is an essential part of all aspects of my career. As an interdisciplinary researcher, my research life depends on effectively communicating mathematical ideas to scientists with a wide variety of mathematical backgrounds. Thus, even while acting as a researcher, I must always wear my teaching cap. In the classroom setting, I strive to create an atmosphere where students are comfortable and motivated to learn regardless of their academic backgrounds.

Many of the courses that I have taught and developed have been interdisciplinary. For reference, I have attached the syllabus of one of the courses. The primary challenge in teaching these courses is that the students have been trained in diverse academic fields. Consequently, my chief aim is to make the course material accessible to students who have been trained in either the mathematical or biological sciences. To accomplish this end, I carefully define biological terms, thoroughly explain basic mathematical concepts, assign group work that enables students to learn from each other, and require final projects that allow students to tailor the tools and techniques learned in the course to their unique academic backgrounds. I also meet each student individually to suggest topics for their research, to discuss their final projects, and to offer advice on how they can better equip themselves to understand the material they study.

Many of the courses I have developed incorporate computer labs where students code mathematical models and perform numerical experiments. These labs enable students to gain mathematical intuition about the systems they study and make mathematical equations more accessible to students who have been trained in the biological sciences.

Becoming a better teacher is a career long commitment for me. Since arriving at Michigan, I have benefited from several resources, both in the department and throughout the university, which have improved my teaching skills. Michigan's Center for Research on Learning and Teaching (CRLT) has been an important source of feedback. At my initiative, they observed my teaching in several courses, have provided me with constructive criticism, and have met with me to discuss how I can improve my instruction in the future. I consider the adjustments that I have made in my teaching style, as a result of this feedback, not as an end, but as the beginning of a long journey of growth. Throughout this journey, I hope to rely on CRLT.

In my courses, I strive to teach both the tools of mathematics and how these tools can be applied. Rather than only teaching facts, I frequently present wrong theories, and encourage students to question them. Instead of merely presenting a published mathematical model, I encourage students to think through the thought process used to develop the model. Together we explore the biological and historical context in which the model was conceived. This includes discussions of why ideas, which now are rarely questioned, were so important when they were presented. These teaching techniques will help motivate students, and improve their critical thinking skills.

Students respond positively to many of the teaching techniques I employ. I list in an appendix comments from several of my favorite, recent confidential student evaluations.

To encourage students in other disciplines, I volunteer one or two week modules in several courses across campus. These include courses in Bioinformatics, Circadian Biology and Synthetic Biology. I do this to demonstrate the importance of modeling to students who have had little or no exposure to modeling. Sometimes, these modules are highlighted in the overall course confidential evaluations, e.g. "I found this course surprisingly interesting. I especially value the introduction to modeling. I went from not understanding modeling at all, to being able to think in terms of models, and now I see how thinking of models, even without actually writing equations or programming can be a good way to guide your thoughts and ideas."

Away from the classroom, I value training undergraduates, graduate students and post-doctoral researchers as an important part of my work. So far, I have:

- Advised 2 students as their summer mentor through the Research Experience for Undergraduates Program
- Served as a co-mentor of Michigan's Undergraduate Synthetic Biology Team
- Led a 2-year team of undergraduates, with experimentalist Alex Ninfa, through Michigan's Research Training Program for Undergraduate Students in Biological and Mathematical Sciences

- Served as the primary advisor for a graduate student and as the co-advisor of another
- Served as the mentor of two post-doctoral researchers and as the co-mentor of another

Many of the success stories I have shared with these students and post-docs are highlighted in my research statement.

One of the undergraduates I mentored was Choon Kiat Sim. We developed the first mathematical model of the electrophysiology of a clock neuron. It was published in one of the leading journals in the field and was the most read original research article in that journal. Choon is now pursuing similar interdisciplinary work as a Stanford graduate student.

Casey Diekman was a graduate student in Industrial and Operations Engineering who decided to take one of my courses in mathematical biology in the fall of 2006. Based on his experience in this course, he switched his graduate field. I am now his advisor. Casey has made remarkable progress and has already given talks at the annual meeting of the Society for Neuroscience and the biannual meeting of the Society for Research on Biological Rhythms.

My time at Michigan has afforded me the privilege of interacting with some extremely talented students. Teaching them is a very important responsibility. It has also been a lot of fun.

Student Comments:

- "I have not met a professor as perfect in teaching style, concern for student's understanding and inspiring as Prof. Forger."
- "This course was great. I learned a lot and fell that I got attention from the instructor whenever I wanted it."
- "Danny cares about students."
- "I learned a great deal from this course. I especially liked the design b/c it encouraged me to read literature and think of my own models to develop."
- The "instructor is clearly an expert in the field, and his passion of the subject material really comes through in his lectures. A great course overall."

Description of Math 564, which I developed: **Modeling and Analysis of Biological Oscillators**

Background and Goals: From sleeping patterns, heartbeats, locomotion and firefly flashing to the treatment of cancer, diabetes and neurological disorders, oscillations are of great importance in biology and medicine. Mathematical modeling and analysis are needed to understand what causes these oscillations to emerge, properties of their period and amplitude and how they synchronize to signals from other oscillators or from the external world. The goal of this course will be to teach students how to take real biological data, convert it to a system of equations and simulate and/or analyze these equations.

Content: Models will typically use ordinary differential equations.
Mathematical techniques introduced in this course include 1) the method of averaging 2) harmonic balance 3) Fourier techniques 4) entrainment and coupling of oscillators 4) phase plane analysis and 5) various techniques from the theory of dynamical systems. Emphasis will be placed on primary sources (papers from the literature) particularly those in the biological sciences. Consideration will be given in the problem sets and course project to interdisciplinary student backgrounds. Teamwork will be encouraged.

Lecture Schedule

Why model? Overview of Biological Problems, Some Definitons (Jan 5)
Simulating with Mathematica (Jan 10)

Biochemical Oscillations:

Goodwin's lucky mistake (Jan 12, Jan 17)
Realistic Models (Jan 19, Jan 24)
Poincare-Bendixson (Jan 26)
Period control (Jan 31)
Modes, Dimensional reduction (Feb 2)

Drosophila eclosion:

Winfree, PRCs and phaseless set (Feb 7, Feb 9)

Fireflies flashing and heartbeats:

Coupled Oscillators (Feb 14, Feb 16)

Neuronal Oscillations:

Introduction to Neuronal Models (Feb 21)
Type1/Type 2 (Feb 23)
Noise and the subcritical Hopf Bifurcation (Mar 7)

Ovulation and electroencephalograms:

Noise Induced Oscillations (Mar 9, Mar 14)

Modeling Circadian Performance:

Introduction to Human Models (Mar 16)
Averaging (Mar 21, Mar 23)
Harmonic Balance (Mar 28)
Synchronization (Mar 30, Apr 4)
Analyzing Data (Apr 6)
Optimal Stimuli (Apr 11)