Teaching Statement—Alex Barnett

My goals in teaching mathematics are to present the concepts in the simplest, most transparent way, to ensure students become fluent and confident in their problem-solving skills, and to transmit the sense of joy and excitement I feel as the mathematical structures and possibilities unfold. The moment when a student successfully grasps a new concept is a deeply satisfying experience for me.

Collaborative learning and visualization

My first teaching experiences were leading discussion sections in physics, which I did for several years for a wide range of courses from introductory physics to graduate-level quantum mechanics, and laboratory electronics. I received five awards during this time, each of which required an average of at least 4.5 out of 5 points in anonymous university-wide evaluations.[1] I was profoundly influenced by the *peer instruction* method pioneered by Eric Mazur,[2], where small-group interaction fosters collaborative learning of concepts. Peer instruction, in the form of worksheets, is now a regular feature of my medium-sized math classes: after about half an hour of lecture, students work together in twos or threes discussing and arguing with each other, filling in a sheet of problems, while I move around the room helping out and asking leading or probing questions. An example worksheet would start with students drawing in extrema and gradient vectors onto a contour plot, then discovering for themselves how the Lagrange multiplier works. In this way I get immediate feedback on where the trouble-spots are, the whole class is involved in active problem-solving, the energy level is high, and the good students explain things to the struggling students often better than I could myself. I also rapidly get to know the class on an individual basis. After 15 minutes I call on groups to explain the solutions to the class, and we tidy up any loose ends at the blackboard. Due to the break in format, the class is now ready to focus on the next idea in the lecture. I have found this technique to be highly effective at engaging students of all levels, particularly for visualization skills, key to success in advanced calculus courses.

In large or medium-sized lectures one of the greatest challenges I find is to engage students who are used to being bored or confused by math. I make extensive use of visual aids (for instance 2-foot-long 'vectors' to illustrate geometric concepts in linear algebra, balloons for iso-surfaces), pose questions to the class (and collect several responses or have a vote of hands), teach by example (working from a special case to the general result), and always bring and use several bright colors of chalk! All my courses have (visually-engaging) websites with additional materials and links[3], and I help students via email on a daily basis. Lecturing is performative, and I maintain a healthy sense of humor, choosing entertaining (but not distracting) real-world examples. I try to teach each new idea in three ways: algebraically, verbally, and visually. I find that geometric intuition is helpful to many students as a key to algebra and problem-solving. For many, the impression of math that they carry for the rest of their life is formed as an undergraduate. Therefore I emphasize the beauty and real-world relevance as well as the rigor of the subject.

[1] Harold T. White Prize twice, Harvard University Certificate of Distinction in Teaching three times.
[2] For more information on this NSF-funded project see `http://mazur-www.harvard.edu/education`
[3] `http://www.cims.nyu.edu/~barnett`

Exams and grading

It is very important to be consistent in one's expectations of students. Matching the difficulty of exams to that of homework questions and lecture examples is crucial for the student to feel fairly treated. In the syllabus I lay down on day one the timeline and grading policy. In lecture I explicitly show the students the types of problems they need to practise. Exams are often the downfall of otherwise competent students, so I provide tactics for study, exam technique and time-management. I design exams that test the basics, but also contain harder material that only an A student should be able to solve. I encourage students to dissect exactly what went wrong in quizzes and exams, since this is the surest key to increasing reliability. I am careful to make multiple versions of quizzes if they are to be used in recitation sections at different times, in order to remove the possibility of cheating. I work with my teaching assistants in weekly meetings to get feedback and ensure consistency in grading.

Project-based courses and vertical integration

As a Courant Instructor I have lectured five semesters of undergraduate mathematics courses,[4] ranging from introductory calculus with business applications, to research-based courses for seniors in the math honors program. These latter courses were in the format of an *undergraduate math laboratory*, where students, a postdoc and a faculty member collaborate on research projects in a small group setting, and undertake (often computer-based) investigations relevant to current topics of interest. This embodies the idea of *vertical integration of research and education* (and was part of Courant's VIGRE program). The first was in collaboration with Peter Sarnak and Steve Miller on prime numbers and random matrix theory; the second, *Mathematical Wave Dynamics*, was with Oliver Bühler on linear and non-linear wave theory and phenomena in nature. We developed extensive sets of original lecture notes for both courses. We demanded that the students grasp tough material, remain focused on project goals, and learn to give clear oral presentations and written reports, all essential skills for a future in research. All student projects, notes, links, and computer codes are available online (see above URL). In the second course I also made frequent in-class use of java applets and MATLAB animations via a laptop and LCD projector.

Confidence and the classroom environment

At Harvard's Derek Bok Center for Teaching and Learning I learned the importance of creating a non-competitive classroom environment where all students are comfortable asking questions. (I later became a 'microteaching facilitator' with the Center, helping take incoming graduate students through their first simulated 15-minute teaching sessions, discussing with them as we watched them on video afterwards). As I teach I strive to keep in mind the perspective of a student seeing the material for the first time. Many students, particularly women, have been branded with the idea that math is not for them; increasing their confidence is vital. I stress that math does not differ from French baseball in the sense that fluency and confidence come only with practice. I take the time to guide individual students,

[4]with student evaluations typically 4.5 out of 5.

listening to the way they grasp the material, and incorporate this into later lectures. I help set up study groups. When posing questions in class I make an effort to avoid the set of students who raise their hand for every question, and to engage those who have not answered in a while. If they contribute a useful idea I work that into my discussion, crediting their contribution.

Course development and the future

I collaborated as head teaching fellow with my thesis advisor creating a new course for non-science majors, *The Physics of Music of Sound*. I developed content and an investigative worksheet-based laboratory component from scratch. I relished the challenge of inventing ways that students with limited mathematical background could grasp more advanced concepts such as Fourier synthesis and the harmonic series.

I am keen to create a similar mathematics course on sound and music (one of my passions), taking one of the following forms. a) An introductory (or non-science major) course involving concepts such as scales, tuning systems, geometric series, signals and periodic functions, waves, musical instruments, resonance, and the voice. Many concepts from calculus and applied mathematics could be integrated into this framework. b) An advanced course for math majors, involving project-based work including numerical analysis, the Helmholtz equation, modeling of musical instruments, drums, flared horns, wave propagation, and architectural acoustics. I am excited by the idea of creating cross-disciplinary courses.

I am aware that my teaching can and should continually improve: I have undergone voluntary *small-group assessment* provided by NYU's Center for Teaching Excellence, and used the results to improve lecturing style. In every class I make use of anonymous student feedback forms, and take the comments seriously. I look forward to the challenge of making mathematics a joyful and successful student experience.