1 Teaching Approach

When I tell people that I am a mathematics professor, they frequently tell me about how terrible their calculus instructor was in college, even many years after the fact. Math professors have a lot of work to do to overcome these perceptions! I have tried to approach my classroom teaching with my friends’ and acquaintances’ comments in mind.

First, I recognize that the students’ emotional comfort level in the classroom is critical to their learning mathematics. Students often feel intimidated by the challenging material. Additional discomfort or hesitation in asking questions, answering questions, or in interacting with one another or with me will only exacerbate their predicament. The students need to feel comfortable enough to ask (what they think are) stupid questions, to express confusion, and to answer questions incorrectly. The students need to feel that they can solve the problems, although not always on the first try. If I am an instructor who is aloof, cold, condescending, or who fails to acknowledge their struggles, then I am not a successful teacher.

Second, I realize that for our upper-level applied math courses (the majority of my teaching so far), I must balance ideas and practice. The students in these courses are not mathematics majors. They come from a variety of backgrounds and, while they are proficient at mathematics, they are primarily interested in using math and in problem-solving skills for another discipline (e.g., engineering). In Math 454, Boundary value problems for partial differential equations, for example, I break down the material into theoretical concepts and a set of problem-solving techniques. The first part of the course entails learning how to solve one differential equation. We walk through a series of steps to do this and apply the techniques one step at a time. Next, we discuss how all problems which share the same structure as our first example are solved with these same steps. This discussion is challenging for students because they have to move from applying an algorithm for solving a problem to abstractly understanding what that algorithm does. They move from practice to ideas. The third part of the course is a return to practice from ideas but with a sophisticated addition to that practice. They must recognize problems that share this structure and be able to apply the same ideas and algorithm from before but to tailor its application to each different specific problem setting.

Third, I want students to be surprised, curious, and excited about mathematics. I want them to feel involved in the course and the material. I want them to participate not simply for the sake of answering questions in class but to have a stake in the outcome of the class or that day’s lecture. Math 425, Introduction to probability, is a class in which I was able to do this easily. There is the well-known Birthday Paradox in probability which surprises students and engages them in the material. In a class of more than about 30 students, there is a 70% chance that two people share the same birthday. At first glance, this seems unlikely. There are 365 days in the year and only 30 people in the room. First, I asked the students to vote—do two people in the class share the same birthday or not? Next, I went around the room asking everyone his or her birthday. We gathered the data and wrote down the days on the chalkboard. When we found two people with the same birthday, everyone could see this from our chart on the board. My class even had two pairs of people who share the same birthday. We then discussed the mathematics behind this seemingly surprising phenomenon. One student in the class was a Resident Assistant in his dorm and ran this experiment there. He also wanted to generalize the example to groups of three and four people with the same birthdays.

Finally, I see my time in the classroom as just one aspect of my teaching responsibilities. I am a teacher not only when I am presenting material in the classroom but also when I am directing undergraduate and graduate students in their research, guiding students in preparing talks and writing up their results, setting an example for students in collaborations with mathematicians, engineers, and scientists, and helping graduate students and postdocs formulate their own research agendas. For example, with the summer students I supervised at AT&T Labs-Research, we went through several stages together in solving problems. First, we interacted with domain experts to find out what they thought was important about the problem. We tried
to tease out of them what precise problem they wanted solved as these experts know what is important but often cannot articulate the problem precisely. In the next step, we defined a rigorous precise mathematical problem from our interactions with the domain experts. We then tried to find a rigorous solution. Often, we had to acknowledge that an approximate or even heuristic solution was either the only achievable solution or was sufficient for the application. To determine when or if we had an acceptable solution, we interacted with the domain experts again to understand the impact of our solution, to refine the solution, and to present the solution in the way that emphasized its impact most clearly. The final step in this process which moves the project from application to research was to go beyond the specific problem, to treat it as a point of departure for further exploration.

2 Teaching Responsibilities

2.1 Courses taught

- Math 650, Winter 2006 Fourier analysis
- Math 425, Fall 2005 Introduction to probability
- Math 454, Fall 2005 Boundary value problems for partial differential equations
- Math 454, Fall 2004 Boundary value problems for partial differential equations
- Math 450, Fall 2004 Advanced mathematics for engineers

2.2 Students supervised

1. Summer students

   - Yi Wang (Univ. of Michigan, EECS Dept.), Univ. of Michigan, 2006.
   - Kirill Levchenko (Univ. of California San Diego, Computer Science Dept.), AT&T Labs-Research, 2003.
   - Joel Tropp (Univ. of Texas, Comp. and Appl. Math. Program), AT&T Labs-Research, 2002.
   - Jing Zou (Princeton University, Program in Appl. and Comp. Math.), AT&T Labs-Research, 2002.
   - Maya Gupta (Stanford University, EE Dept.), AT&T Labs-Research, 2000.
   - Stephane Seuret (ENST), AT&T Labs-Research, 1999.
   - Youngmi Joo (Stanford University, Computer Science Dept.), AT&T Labs-Research, 1999.

2. Research Experience for Undergraduate (REU) students

   - Daniel Sikora, University of Michigan, 2005. Daniel worked on a coding theory project. He presented his project at an American Mathematical Society (AMS) sectional meeting.

3. Ph.D. students

   - Ray Maleh, Department of Mathematics, University of Michigan, expected graduation date 2008.
   - Served on the Ph.D. committee of Thiradet Jiarasuksakun, Department of Mathematics, University of Michigan, 2006.
• Served on the Ph.D. committee of Earl Lawrence, Department of Statistics, University of Michigan, 2005.

• Joel Tropp, *Topics in Sparse Approximation*, University of Texas at Austin (joint with Inderjit S. Dhillon, Dept. of Computer Science, UT-Austin), 2004.

### 2.3 Mentoring

- Official mentor of Geri Izbecki, AIM graduate student, Univ. of Michigan. We have met several times per semester. We have discussed her struggles with the AIM qualifying exams and her thoughts on choosing an advisor. Geri and I have also discussed her experiences with two summer internships at national laboratories.

- Unofficial mentor of Ruth Miller, undergraduate mathematics major, Univ. of Michigan. Ruth was in Math 425 which I taught in Fall 2005. At the time, she was a mathematics education major and was student-teaching. She was not happy with her student-teaching experience and came to talk to me about being a math major. She loves doing mathematics but had questions about what kind of job she could get with a degree in math. We have talked several times about career options for her and about how to finish her mathematics degree.

- Unofficial mentor of Joel Tropp, postdoctoral assistant professor, Dept. of Mathematics, Univ. of Michigan. Joel was both a summer student at AT&T Labs-Research and my graduate student. Now, he is an NSF postdoctoral fellow at the University of Michigan. Over the years we have known each other, he has developed into a close collaborator and rising star researcher.

### 2.4 Outreach


- Invited speaker and panelist at Park City Mathematics Institute (PCMI) summer program for women (held at Institute for Advanced Study), 1998 and 2004.

### 3 Teaching Effectiveness

Classroom teaching has been my biggest challenge since joining the faculty at the University of Michigan. I had done very little teaching of this type in graduate school and in my previous job at AT&T Labs-Research. I had a rough start and received one especially poor evaluation in the Fall of 2004.

In order to improve my classroom teaching, I undertook a number of tasks. First, I spoke with the other instructors of the same courses to revamp the syllabi and to get a better feel for the pace of the lectures and the difficulty of the homework and exams. I also went over my course evaluations, including individual student comments, with a senior faculty member (Robert Krasny) to understand the students’ comments and to make the appropriate changes where necessary in the course curriculum and in my classroom and office demeanor. I went over these evaluations with a CRLT staff member as well to understand course evaluations more generally. I needed to make particular, specific adjustments to the curriculum at several points in the material. I also needed to gauge the level and amount of the homework better. Finally, while my lectures were clear, the students did not find my classroom personality friendly and supportive.

When I taught a new course (Math 425), I asked to follow a senior faculty member (Sergey Fomin) who was teaching the same course that semester. Another instructor and I followed his course notes, syllabus, and homework. I learned the right pace and depth for the course and adjusted my lectures, exams, and homework assignments accordingly. I also brought in a CRLT staff member to conduct a midterm evaluation with the students. He observed me in the classroom and then met with the students afterwards. When I taught
a graduate course (Math 650), I did an informal midterm survey of the students and responded to their suggestions and comments in the middle of the semester.

All of these activities have been productive. My teaching evaluations have improved every semester I have taught. I have learned how to pace material not only over a single lecture but over an entire semester. I feel more comfortable in the classroom and the students find my classroom personality supportive, energetic, and enthusiastic. I expect my classroom teaching and my evaluations to keep improving as I gain more experience.

The effect of my teaching and mentoring individual students, in REU or summer projects, is harder to measure but I think I am having a positive impact. I am still in contact with several of the students who did summer projects with me at AT&T Labs-Research. One of the REU students at the University of Michigan will be starting a Ph.D. program in electrical engineering at the University of Michigan in fall 2006. One summer student from AT&T Labs-Research is an assistant professor in the electrical engineering department at the University of Washington. A second student is a postdoctoral researcher at Rice University. A third student is a postdoctoral research fellow at the Center for Scientific Computation and Mathematical Modeling (CSCAMM) at the University of Maryland.

4 Teaching Development Activities

I developed a new graduate course, or perhaps revived an old course which had been taught infrequently. Math 650 covers Fourier analysis but it has not been taught frequently in the mathematics department as it is a rather traditional topic and not one of the department’s strengths. I updated the topic to cover wavelet analysis, a significant, more applied aspect of Fourier analysis, and drew students from a wide range of departments, including mathematics, applied mathematics, electrical engineering, and physics. Two of the students in the course were undergraduate mathematics majors. One of them was specializing in statistics and probability. I am currently working on turning this material into an undergraduate course. I have also been working with two senior professors (Kathy Davis and John Gilbert) at the University of Texas-Austin who are running an REU on wavelets (summer 2006) to produce material and research projects appropriate for undergraduates.

I am a founding member of a proposed undergraduate degree program in Information Sciences at University of Michigan. It is an interdisciplinary program that spans statistics, mathematics, and computer science and is an innovative approach to preparing undergraduates for future careers in the sciences and engineering. I am involved in the degree design, the course requirements, and the process to get the program approved by the university. I have agreed to serve as advisor within the mathematics department to students in the degree program. I am a critical member of this program because I have first-hand experience with real-world problems in information science, my research is by nature interdisciplinary and at the intersection of information sciences fields, and I know how to teach students the skills they will need. Students must have a solid foundation in how to analyze information, they must then be able to carry out such analysis, and finally they must understand why such analysis is possible. This is a rigorous scientific program, rather than a professional degree emphasizing the latest technology, because we want to emphasize the science portion of information sciences.