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EXPERIENCES AND GOALS AS AN EDUCATOR

1 Introduction.

When I tell people I study probability and statistics, the response I inevitably receive is, "I had that class in college and I hated it." As an educator, my goal is to dispel the myth that probability and statistics (and the mathematical sciences in general) are inherently boring, difficult subjects. I strive to help my students develop an appreciation of these disciplines and their importance and usefulness in everyday life. I believe this is best accomplished by mentoring students and creating educational experiences that engage students in active learning, emphasize fundamental concepts, and develop problem-solving skills.

In this document, I discuss my experiences and goals as an educator. Links to many of the items described below (undergraduate research paper, lectures slides, course notes, etc.) can be found at: `http://www-stat.stanford.edu/~kjross/teaching.html`.

2 Mentoring students.

Undergraduate research supervision. In the summer of 2008 I worked on an eight-week research project with an undergraduate student. The student and I met several times a week over the course of the project. The student was interested in stochastic optimal control, and while he had taken Stat219 (described below) and a course in discrete time stochastic processes, he had no background in stochastic differential equations/diffusion processes or partial differential equations — some of the essential tools in stochastic control theory. Given the student's background and interests — and the eight-week time frame — my objectives were to introduce the basic principles of stochastic control while avoiding many of the more technical details. To this end, we studied a control problem for Brownian motion in two-dimensions, and through explicit computations (arising from properties of Brownian motion) we proved a property of an optimal control. We also employed Markov chain approximations to compute near optimal controls. The numerical component served two goals: to introduce the theory of discrete time stochastic control (and dynamic programming) and to tackle important computational issues.

Financial mathematics. I am an informal adviser for many of the students in the Master of Science in Financial Mathematics (MS-FM) program at Stanford. I help students select courses that best meet their interests and career goals. Some of the students go on to Ph.D. programs, and I advise them in choosing programs and in composing their applications. Also, I have served on the MS-FM admissions committee and, as a result, have have gained insight into finding successful matches between students and programs.

Through my affiliation with the MS-FM program, I have also gained valuable insight into the industrial side of the discipline. As an organizer of the Financial Mathematics seminar, I have recruited financial mathematicians at top firms to lecture to and mentor current students, advising them on the current state of the field.

Actuarial experience. In addition to my university experience, I taught several classes in actuarial mathematics while working at Towers Perrin. I also routinely worked one-on-one with new employees, training them in the various aspects of the actuarial profession and mentoring them in their career development. My professional experience as an actuary gives me a firsthand perspective that is a valuable asset when advising students in their actuarial exam preparations and job searches.

Introductory statistics. In an introductory statistics class, mentoring students is critical for non-majors and majors alike. Many non-majors (usually the large majority of students) arrive to the first class full of negative attitudes, mathematics anxiety, and pressure to do well to get into a specific program. My job is to encourage and reassure students that they can learn statistics regardless of their mathematics background. I help students build confidence by offering guidance and challenging them to answer their own questions, instead of just giving them the answers. Many non-majors will take only one, required, statistics class. If these students are to see the relevance of statistics in their careers, it is essential that they have a positive course experience. Having an instructor who is actively engaged in their learning process will encourage them to take the class — and the subject — seriously. As one student wrote in his course evaluation,"it was clear to everyone that you were interested in us as people, not just as students, and that's what makes you a great professor."

3 Curriculum development.

Creation of Stat220. In spring 2008 I created a new course at Stanford, Stat220: Continuous Time Stochastic Processes. Students were assumed to have taken Stat219 and a course in stochastic differential equations (at about the same level of rigor as Stat219). My goal was to present a rigorous theory for a variety of continuous time stochastic control problems (classical diffusion control, optimal stopping, singular control, etc.), without developing the subject in full generality (thus avoiding many of the technicalities involved). Class size was small (9 enrolled students) which allowed for a great deal of interaction during lecture. I also took advantage of the small class size to tailor the course topics to student interests, in particular in financial mathematics. Since I know of no text appropriate for the above objectives given the student backgrounds, I wrote lecture notes to use as the textbook. Feedback on the first draft of these notes was positive, and I look forward to revising and improving the notes — and this course — in the future.

Development of Stat219. At Stanford I teach a non-traditional master's level course in measure-theoretic probability and stochastic processes (Stat219). A typical class has 50–60 students with the following profile: 20% Ph.D. students, 60% master's students, 20% upper level undergraduates; with majors 40% in financial mathematics, 20% in mathematics, 20% in statistics, 20% in a mix of engineering, economics, and business. The goal is to help students understand the basic concepts of measure theory that are relevant to the mathematical theory of probability and how they apply to the rigorous construction of the most fundamental classes of stochastic processes. The list of topics covered in the class is rather long, including: basics of measure theory and Lebesgue integration, probability spaces, random variables, types of convergence, conditional expectation, stochastic processes in discrete and continuous time, sample path properties, filtrations, Brownian motion, Poisson process, martingales, and Markov processes.

As is clear from the preceding, it normally takes more than a year to cover the scope of this class. Even more so, given that the intended audience for this course has only minimal prior exposure to stochastic processes (beyond the usual undergraduate probability class). While students are assumed to have taken a real analysis class dealing with Riemann integration, no prior knowledge of measure theory is assumed. The unusual solution to this set of constraints is to provide rigorous definitions, examples, and theorem statements, while forgoing the proofs of all but the most easy derivations. At this somewhat superficial level, one can cover everything in a one quarter course of thirty lecture hours, albeit at a very fast pace.

Such a course presents many challenges. The first is the lack of an appropriate textbook. Amir Dembo has written lecture notes as a primary source for the class. Based on student feedback, I have revised the notes to include more examples, exercises, and illustrations, and to remove or deemphasize some of the more technical topics. As a result of my revisions, the notes more closely resemble a true textbook.

Another challenge is the amount of material covered over the short duration of the course. In order to manage the fast pace, I created simple slides for use during lectures. These slides (about ten per fifty minute lecture) contain only basic information, such as precise statements of definitions, assumptions, and theorems. Not having to write this information on the board allows me to devote more class time to explaining key concepts and working through examples, allowing me to cover the course material "without making it too rushed." Many students also value the slides as a supplemental text.

4 Active learning, conceptual understanding, and problem-solving skills.

I structure my courses so that they engage students in active learning, emphasize fundamental concepts, and develop problem-solving skills. I now discuss some of my methods in two courses: first in an introductory statistics class, and then in Stat219. While these courses are aimed at vastly different audiences, the same educational principles apply in both settings.

Introductory statistics. The best way for students to learn statistics is to do statistics. Thus, each class meeting should incorporate some active learning activity. Examples include: analyzing a small data set, writing a paragraph explaining a statistical concept in simple terms, or reading a newspaper article and discussing its statistical merit. Classroom activities satisfy several objectives. First, activities give students opportunities to develop their own statistical reasoning and problem-solving skills. Second, allowing students to work in groups during activities gives them valuable practice speaking the language of statistics, and exposes them to perspectives other than just the instructor's. Third, classroom activities are a valuable assessment tool. Upon introducing new topics, the instructor — and students — can immediately identify in class areas where help is needed.

A solid conceptual understanding of statistical principles is key to an appreciation of the subject. There are several ways in which I emphasize statistical concepts in my classes. First, I motivate new topics with a question or example, rather than simply putting a definition or formula on the board. Second, I continually make links between material covered during different parts of the course to keep the "big picture" in mind. For instance, when performing a hypothesis test, I refer students to the sampling design in deciding what conclusions are appropriate. Third, I routinely use software, applets, graphics, and simulations in class to visually illustrate important statistical concepts and methods. Students understand the central limit theorem more fully by seeing it in action rather than as another formula to memorize. With a solid foundation in basic statistical concepts and problem-solving skills, students are well prepared to handle even advanced statistical methods encountered in subsequent classes or real world applications.

Although exams have comprised a large percentage of course grades in classes I have taught, I have assigned small projects with positive results. Student projects are an excellent assessment tool which I will integrate more fully in future classes. Projects satisfy several pedagogical goals. First, students can choose a topic of interest to them, and thus they witness the importance of statistics in a familiar context. Second, students learn statistics by practicing it from start to finish, from defining the initial problem to interpreting results and making conclusions. Thus, students experience the big picture of the practice of statistics. Third, projects assess ability both to produce statistics (has the student: used statistical methods appropriately? performed calculations accurately?), and to consume statistics (has the student: interpreted results properly? communicated results effectively?). Finally, students gain valuable practical experience using software such as R or Microsoft Excel to perform computations and display information.

Stat219. To incorporate active learning, I typically ask true or false questions during lecture. All the students "vote" true or false and several students from each side state their case. Then we discuss the results, identifying any flaws in the reasoning presented, and providing a proof or constructing a counterexample. Such a strategy fits very well within the goals of this particular course, but I believe it will be effective in many other courses, even at the Ph.D. level.

The main goal of the course is to develop within the students a conceptual understanding of the course topics. In addition to providing colloquial interpretations of key concepts (filtrations as "information", martingales as "fair games", etc.) I routinely use plots and pictures to illustrate key ideas. Moreover, in order to emphasize more strongly the dynamic nature of stochastic processes, I have created several "movies" for the class. Examples include: a movie depicting (approximately) Brownian motion on a line, along with the evolution of the corresponding sample path over time; and a movie illustrating the convergence of scaled random walks to Brownian motion. While the production values are far from Oscar-worthy, the students seem to enjoy the movies, and seeing a concept in action helps foster their understanding of it.

5 Teaching evaluations and my future as an educator.

I continually am searching for ways to be a more effective teacher. Student feedback is a valuable asset in this process. A few weeks into the term, I ask students to fill out feedback forms that address issues from classroom mechanics to level of interest in course material, so that I can identify and fix any problems early on. Students also complete departmental course evaluations at the end of the term. A summary of these evaluations appears below. (The highest score is 5.)

	Number of students	Instructor mean score	Course mean score
Stat220, 2008	9	4.67	4.67
Stat219, 2007	59	4.27	4.23
Stat217, 2007	28	4.41	4.41
Stat219, 2006	51	4.38	4.12
Intro Stat, 2005 (at UNC)	98	4.10	4.10

These anonymous reviews consistently have rated my teaching highly, commending in particular my organization, enthusiasm, availability for help, and concern for student performance. I was extremely honored to receive a departmental teaching award in 2004.

Through my previous experience I have proven that I am capable of teaching a variety of courses in the mathematical sciences from introductory to graduate levels, and I am excited for new teaching opportunities. I also am well prepared to work with students on research projects, and to advise students in careers in mathematics and statistics.

Working with students always will be an integral part of my career. Even while working as an actuary, I constantly sought out opportunities to teach. I enjoy getting to know students and providing them with opportunities for intellectual growth. I cherish sharing the sense of accomplishment when everything clicks into place for students who struggle with some material. Seeing students become interested in a topic keeps me energized in my own research. In my career, I hope that my enthusiasm for the subject and love of teaching will instill in my students excitement for learning probability and statistics. If I do my job well, when my students encounter a probabilist or a statistician they'll say, "I had that class in college and it was great!"