TEACHING STATEMENT

Alan J. Lockett

The research university holds a critical role in modern society as the first stage of education when the student comes into full contact with the idea that the state of human knowledge is a work in progress. In my view, the task of a university educator is to cultivate in students a fundamentally inquisitive outlook that seeks to discover the intuitive and logical underpinnings of their fields. This curiosity should drive the student to acquire a knowledge of and respect for the traditions and conventions that have allowed the field to advance to its present state. At the same time, it should reveal the ways in which those same traditions and conventions are inadequate to express or solve many important and interesting problems. With hard work and dedication, informed curiosity will lead students to discover new problems and new ways of solving them on their own. Respect and understanding of what has come before will help them persuade and convince others of the relevance of their ideas.

The goal of classroom teaching, even in large lecture courses, is thus not merely to communicate a program of information, but to show students the historical context of an idea along with its importance in the present. For example, within measure theory, the concept of *measurability* was introduced in order to avoid problems such as the Banach-Tarski paradox, in which the three-dimensional unit ball can be decomposed into finite subsets that can then be rotated and translated to construct two balls with the same volume as the original. This paradox provides a conceptual tool that helps students grasp the relevance of *unmeasurable sets* and motivates the need for σ-algebras to provide a rational notion of volume. The idea of limiting measurable sets leads directly to the concept within probability theory of the σ-algebra as a source of information about what events can be observed. A discussion of this sort provides a gentle and rational introduction to measurability and σ-algebras, which are perhaps the most confusing aspects of probability theory for undergraduates.

By focusing on core concepts such as measurability, the student can begin to understand *why* the basic definitions, axioms, and theorems take the form they do. This understanding forms a frame to which the student can attach various facts as needed. It also becomes a launching point for new explorations. For instance, a student might ask whether the existence of unmeasurable sets is merely a symptom of the inadequacy of our understanding of space. The student could branch out from there to learn about the axiom of choice, or pointless topology, or other approaches that characterize space without resulting in unmeasurable sets. The pursuit of such questions will eventually lead some students to the edge of what is known, after which they can seek to make their own research contributions.

Thus my approach to teaching basic courses, whether probability theory, statistics for engineers, or theory of optimization, consists in identifying a handful of core concepts that connect the various details. All the material in the course, including lectures, homework, and exams, will be organized to constantly reinforce these few themes, so that the student is given a basic structure on which to attach the important details. The concepts for statistics include: 1) random variables as tools for measuring information, 2) dependence and independence, 3) statistical hypothesis testing, and 4) the Central Limit Theorem. For theory of optimization, the core concepts include: 1) the inherently heuristic nature of iterative optimization methods, 2) the role of search bias in determining efficiency, and 3) the utility of changing the problem to improve performance (e.g. hidden variables, Lagrangians, duality). By mastering concepts such as these, the student gains the intuitive framework needed to acquire more detailed knowledge.

When teaching large lecture courses, direct student interaction can be limited, and I feel it is important to obtain feedback from the students at regular intervals in order to ensure that students who apply themselves can learn the material without confusion. In order to get feedback, I will employ a variety of techniques. Every few weeks, I will remind students that they are welcome to come to my office to discuss the course, either at posted hours or by appointment. At mid-semester, I will distribute a two or three question survey to be completed by students optionally and anonymously, containing questions such as: 1) Have I clearly communicated the course material thus far, and if not, what remains unclear?, 2) What is the most difficult concept you have encountered in this course?, and 3) What positive action can you take in order to get more out of this course? Finally, once mid-term exams are completed, I will identify five or six students who appear to be struggling either far too much or far too little. I will personally invite these students to my office to discuss what they have learned or are not learning well, to encourage them and to gain insights on how the class could be better.

At the master's level, I will eventually develop a two-semester seminar course on optimal decision-making in uncertain environments with applications to the control of complex autonomous systems, based on my research work. The course will be project-oriented and intended to introduce students to research, with the first semester designed to help the student explore the field, choose a project topic, and verify the concept. In the second semester, the student continues research on a successful topic or choose a new topic for research. During the first semester, an initial set of readings and discussions lasting about a month introduces basic conceptualizations of sensor systems, embodied learning, and decision theory. Students then choose to focus on either theory or application, specifying an area of interest. Over the course of the next three weeks, each student completes individually assigned readings or research in their area of interest and then takes turns preparing a two to five page summary document along with a 15 minute presentation for the class. Each student then prepares a project proposal in either theory or applications, again presented to the class for commentary and discussion. This project should consist of a proof-of-concept verification phase that should be feasible within a month to complete the first semester, along with a second-stage follow-on proposal for the next semester that could result in a short publication if successful. In the last month of the first semester, students complete the verification phase of their proposal, presenting it to the class for commentary and completing a 10-20 page document describing their final results. The student's evaluation for the semester will be based first on the quality of their project presentations and papers and second on their engagement in class.

Students that wish to continue their project can enroll for the second semester. This second semester begins with a detailed project proposal, followed by periodic presentations and reports from each student on the status of their project. Later in the semester, these reports would take the form of paper drafts. The final result is a 30-45 minute presentation together with a complete research paper of publishable quality. An example research topic for the theory track might be to derive optimal controls analytically with respect to a simplified model of an environment, sensors and actuators. Another topic might be to explore the convergence rate or lack of convergence for a particular learning approach. For the applications track, a student might propose to implement a certain type of control and subject it to experiments, perhaps even a control method being studied theoretically by another student in the class. By the end of the course, the student should have a well-developed beginning for a Master's thesis.

Thus at each stage of the student's progress, my goal as a university instructor is to gradually introduce students to the concept of knowledge as a human artifact whose future development depends in part on them. In early lecture courses, I will help the student to identify and understand the core questions that drive current research. In later graduate coursework, I will mentor the student to participate actively in the advancement of human knowledge and ability. In this way, I will support the university's goal of preparing students to contribute meaningfully to society.