Teaching Statement

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September 2007

1 Introduction

I find teaching to be one the most challenging yet rewarding aspects of being a professor. The biggest challenges for me are in understanding the preparation of students and in finding a good balance of example and formalism, both of which seem critical in effective classroom teaching. Still teaching brings with it the reward of being able to explore with incredibly smart and energetic students many of the ideas, methods and philosophies that inspired me as a student and continue to inspire me now. I feel especially fortunate to teach students who are interested in the role of engineering and the applied sciences in the wider fabric of society, public policy and business. In view of this, I try to structure teaching to be accessible and intellectually engaging to students with different backgrounds. My main goal in the classroom is to convey complex ideas in their simplest possible form, while inspiring students with the transformative power that computation can have in the world. The rewards of effective pedagogy ultimately provide a nice tonic to the long-term ambitions of research, while teaching also provides, I think, an extremely important opportunity for continual learning and replenishment on the part of the teacher.

My classroom teaching experiences have all been quite different. In teaching a class on “Intelligent Machines,” which provides an introduction to Artificial Intelligence (AI), one particular challenge is to bridge the gap between preconceptions about AI from the popular media and the “nuts and bolts” of engineering intelligent systems, coming in the form of representations, algorithms and theories. The same sweeping breadth of applicability, and promise, that makes AI inspiring also causes challenges in the classroom; one needs to simplify, teach the principles and then situate learning in the richer context of a fielded AI system, perhaps one that involved multiple person-years of development. In teaching my graduate seminar “Topics at the Interface between Computer Science and Economics,” my first task is to introduce students to the concepts from economics and game theory that they will need to be able to read research papers in this area, and to do this with sensitivity and without trivializing, reminding students of subtleties lurking around unexplored turns. With this background in place, my role pivots to one of facilitator in discussing research papers as a group, balancing the need for students to actively learn and express opinions with the need to make sure that false impressions do not ultimately go unaddressed. I have enjoyed teaching a freshman seminar on “electronic transactions,” which provided me the opportunity to explore topics that could form the basis of a new undergraduate course. I also hope to integrate a teaching methodology from this freshman seminar – interactive computational experiments – into a new class on optimization that I will offer in Spring ’08.

In addition to classroom teaching, I have had the opportunity to advise many students in the capacity of freshman advisor, academic advisor and also research advisor. Each brings its own
challenges and rewards but is deeply satisfying. Advising is so very important and I feel honored to be able to make a difference to a student’s academic and personal development, and ultimately to his or her choice of career.

2 Courses

Here I provide brief descriptions of the courses that I have taught and developed. A complete syllabus of each course is enclosed in the dossier.

CS182: Intelligent Machines. This course provides an introduction to the principles of artificial intelligence, with an emphasis on representation, i.e. how to model and formalize information about an agent’s environment, and search, i.e. how to efficiently manage a large, potentially exponential, number of possibilities and make decisions. Topics covered are those related to decision making under certainty, including constraint satisfaction, optimization, logical inference, distributed problem solving, and meta-rationality. This focus nicely complements that of CS 181, which considers decision making under uncertainty, including reinforcement learning, probabilistic inference and Markov decision processes. These two classes provide a nicely balanced, broad introduction to AI.

An over-arching theme in the class is the control of computation: rational decision making typically requires the careful and informed use of heuristics and abstractions, along with making tradeoffs between different kinds of reasoning in order to find good solutions to very difficult problems. I want students to understand that NP-hardness does not preclude solving typical problem instances effectively in practice. The emphasis is on finding the right representations and the right search methodologies for attacking different classes of problems. I also try to emphasize the important role of experimental analysis in complementing theoretical understanding, and in enabling the discovery of new computational approaches.

The course has been a fairly popular offering and is successful in attracting students with broad backgrounds. CS 182 aims to serve at least three communities: CS concentrators with more of a hands-on programming style; CS concentrators with more of a theory style; and non-concentrators that are simply interested in learning something about artificial intelligence. My approach has been to provide a little bit for everyone in lectures and to emphasize the way in which computational thinking, which goes to the heart of the study of AI, can help to understand many systems – biological, social and economic – in the world.

CS 286r: Topics at the Interface between Computer Science and Economics. This is a rotating topics, seminar-style graduate course I have developed to cover emerging topics that intersect computer science and economics. We study topics in computational game theory, agent-mediated electronic commerce, mechanism design, electronic markets, and networked systems. Especially relevant for students doing research in computer science problems with connections to game theory and economics, the class is broadly popular and frequently over-subscribed, attracting students from concentrations such as operations research and economics as well as students interested in theory, systems and AI within computer science. The course has inspired courses at several other universities, and I have been approached by the Cambridge University Press to write a text related to the class.

Once introductory lectures – in which I provide necessary background material – are complete, the bulk of the course is devoted to reading current research papers, with students pairing up
and presenting a paper to the class. I meet with student presenters before class to help them understand the paper, highlight especially important discussion points and suggest priorities for the presentation of results. I also review and distribute comments from students on each paper in advance of class. Both of these steps enable a lively and informed discussion in the classroom. The class culminates in original research or a review of a current research area. A number of class projects have developed into successful senior theses and led to published work. Remarkably, some of the important directions in my own research have found their genesis in the spark of an idea during a classroom discussion.

The course covered the topic of “Computational mechanism design” in Spring ’02, ’05 and ’07, “Electronic market design” in Spring ’03, and “Multi-agent learning and implementation” in Spring ’06. Of special note is that in Spring ’04 the class was dedicated to a single project, that of “Iterative combinatorial exchanges.” Evan Kwerel, senior economic advisor at the FCC, and George Donohue (George Mason U., former associate administrator of the FAA) both visited the class and helped to motivate the need for new market design. Students worked in teams on different aspects of the design of an iterative combinatorial exchange. The class was ambitious, in part because of the difficulties involved in coordinating software development amongst 24 students in the course of one term, but I think ultimately a great success. I would enjoy the opportunity to teach a similar, project-based class, in future years.

**FS 26n: Electronic Transactions.** This is a freshman seminar that I taught in Fall ’06. The full title is “Electronic Transactions: Better Decisions through Economic and Computational Thinking.” I received a course innovation grant from Harvard college, and planned the seminar as a way to explore ideas for an undergraduate class around a similar theme. We read and discussed books and research papers related to a broad set of topics, ranging from the BitTorrent protocol and the evolution of cooperation in repeated games, to prediction markets, to search on complex networks, to methods for combating spam email. The focus of the class was on understanding the many practical problems that are best addressed through the combination of economic and computational thinking. The seminar was structured around four, competitively structured team exercises, as follows: designing finite-state automata to compete in a noisy prisoner-dilemma game; programming agents to compete in prediction markets; exploring variations on local search for clearing combinatorial auctions; and programming agents to compete in a simulated slot auction for sponsored search. Despite my deliberately selecting students with little background in computer science, every student was comfortable modifying Java programs and running experiments by the end of the term. My challenge, in scaling to a lectured version of the seminar, is to find the right way to retain the interactive, hands-on learning experience and strong coupling to real-world problems, while developing the resources to allow students with little background to be comfortable in crafting, and modifying, simple programs.

**AM 121: Introduction to Optimization: Methods and Models.** This is a new undergraduate course, dedicated to bringing the power, elegance and applicability of methods in linear optimization to a wide audience. The course is a significant re-launch and re-design of ES 102. It will continue to serve as a first course for students interested in optimization and decision theory, while being somewhat more focused and significantly more applied than the ES 102 of recent years. Rather than try to provide a comprehensive treatment of all topics in operations research, it is focused on optimization, mainly deterministic but also some stochastic, and almost exclusively linear optimization. I believe that optimization – with its seductive combination of modeling, theory and
practice – can and should have extremely broad appeal at Harvard and expect that AM 121 can expand to attract students from computer science, economics, and the physical sciences in addition to applied mathematics and engineering sciences. If successful, I think AM 121 should eventually be paired with a course on stochastic aspects of operations research, including queuing theory and inventory theory and with an opportunity to include non-linear optimization. Applications in my class will be drawn from business, society, engineering, sports, e-commerce, and medicine. One innovative teaching methodology that I will introduce is that of “extreme optimization,” wherein small teams of students will work on a fairly open-ended modeling and optimization exercise, with codes tested in the classroom on unseen instances and students given the opportunity to discuss what they did and lessons learned. My overarching goal for the course is to get students to appreciate the broad applicability of optimization and to understand the fundamental role of elegant and beautiful, applied mathematics.

Future Teaching. For the next few years I would like to develop AM 121 “Introduction to optimization” into a successful, repeatable class. This year it will be a little difficult to find qualified teaching staff, but this will be much less of a problem in future years. Along with AM 121, I would enjoy the opportunity to be able to develop FS 26n “Electronic transactions” into a full-fledged undergraduate class, probably taught at the freshman and sophomore level and within computer science, perhaps together with a colleague in economics or at Harvard Business School. In teaching these classes, and other similar classes, I hope to contribute to our efforts as a engineering faculty to reach out to more students. Economics, in particular, is a very large concentration, and one in which a number of students should enjoy, and benefit from, more exposure to computer science. In addition to CS 182, I would of course enjoy teaching our other artificial intelligence course (CS 181), and would also be delighted to develop an undergraduate class related to the “Foundations of electronic commerce” or the “Principles of multi-agent systems.”

3 Research Advising

Research advising has proved itself to be a wonderfully fluid, sometimes surprising, often inspiring, and ultimately gratifying experience. I aim to meet with every graduate student in my group weekly, to keep up with their progress and offer guidance on direction and next steps. Every student is very different in character and needs. Some students are very self directed and able to sniff out a good research problem and make good progress with minimal involvement on my part. Other students struggle to find a good problem area, or struggle to formulate the right specific question in a large space of possible questions. Many students fall somewhere in between. Of course, students also differ in their natural strengths; while some students in my group tend to work on theoretical questions, other students prefer more of a computational and experimental style.

I think that what I enjoy most in my role of research advisor is that students continually challenge my assumptions, and offer different views on the right way to think about a problem. I also benefit enormously from the opportunity to learn from students who have a somewhat different technical background than my own, or are taking classes on topics at the periphery of my own comfort level. My “Economics and computer science” (EconCS) research group has weekly meetings in which we present work and invite outside speakers to give talks. This meeting is important in providing students with the wider context of their own research and suggesting new
angles and directions. It is also an easy venue to advertise what we are doing to other research
groups and vice-versa; students and faculty visiting in the Cambridge area frequently contact me
and ask to give a talk. I know that my own students enjoy this opportunity, especially to interact
with peers at other institutions, and I believe that this helps to develop a wider sense of research
community.

I have also been able to co-advise the exceptionally talented students in the Information, Tech-
ology and Management (ITM) – now Science, Technology and Management (STM) – joint Ph.D.
program between SEAS and the Harvard Business School (HBS). This has proved a very interesting
experience. While the students in the ITM/STM program are less motivated to do purely tech-
crical work then our own students, they have unusual maturity, a real interest in finding real-world
(business) application of their research, and the ability to connect with firms and gain access to
data that enables careful empirical research. As a faculty we have also come to recognize that
students will find academic positions in business rather than engineering schools upon graduation.
This, in turn, has led me to temper the extent to which I expect, or indeed encourage students to
participate deeply in my own technical research agenda. On the other hand, I still find plenty of
opportunities to work with students, most recently with David Chen on the economics of interactive
content and marketing on cell phones (co-advised with Prof. Peter Coles in HBS) and with Katy
Milkman on behavioral economic modeling for online shopping (co-advised with Prof. Max Baz-
erman in HBS, and related also to a joint project on generative models of network economies with
Prof. Patrick Wolfe.) From a program administration perspective, I have worked over the years
with my colleagues to ensure students receive an SEAS advisor in their first year, in modifying and
rationalizing course requirements, in the selection and recruitment of students to the program and
most recently as the co-chair of an SEAS committee in making recommendations on the transition
from ITM to STM.

A complete list of all the students I have supervised is contained in my CV, so I will provide
only a brief summary here.

Graduate Students. This Fall, I will graduate my first Ph.D. student in computer science.
Sébastien Lahaie’s dissertation is on the topic of preference elicitation in multi-agent systems. It
is an outstanding thesis, drawing novel connections between preference elicitation, learning theory,
and combinatorial optimization, and including a timely application to sponsored search. Some
chapters have already been presented in leading AI and e-commerce conferences and much more
remains to be published. Sébastien will take a position this Fall with Yahoo! research (New York),
which has quickly built-up an extremely impressive group of economists, computer scientists and
people from operations research. Some believe that Yahoo! research may provide an environment
similar to that at AT&T Labs in the 90’s, this time for innovative, path-breaking research related
to economics and computer science.

I have also graduated two Ph.D. students in the ITM program. Jason Woodard (co-advised with
Prof. Carliss Baldwin, HBS) graduated in May ’06, with a dissertation on the topic of architectural
strategy for modular systems. Jason is now an Assistant Professor in the School of Information
Systems at Singapore Management University. My other ITM student, Adam Juda (co-advised
with Prof. Pai-Ling Yin, HBS now MIT Sloan school), graduated in May ’07 with a dissertation
on coordination problems in electronic markets. After much consideration, he has joined Google
(New York), where he expects to be able to make real-world contributions to the design of efficient,
electronic markets.
Amongst my current Ph.D. students in computer science, Ben Lubin is the recipient of one of twelve Yahoo! Key Technical Challenge grants awarded in Spring’07. Jacomo Corbo is the recipient of a Canadian Fonds de la recherche en santé du Québec fellowship. Of the nine computer science students that I have advised for more than one year, all have published at least one paper in top venues, with fourteen papers published in total in top-tier conferences, two journal publications and many workshop papers. Ruggiero Cavallo’s paper was nominated for the best student paper at AAMAS’06. I have an embarrassment of riches this year, and fully expect to graduate six Ph.D. students in computer science. Two of these students are co-advised with Prof. Margo Seltzer, and one with Prof. Michael Rabin. A number are doing extremely well and will be seeking academic positions. Other than this, I co-advised two Ph.D. students in the ITM/STM program and (co-)advise six, more junior, Ph.D. students in computer science, of whom two are entering first year students.

**Undergraduates.** In addition to my role in advising Ph.D. students, I have worked with many brilliant undergraduates, both in the context of senior thesis work and also through advising independent study. I have closely supervised research for twenty undergraduates (one from Columbia). Of these, four have won Hoopes prizes, four have had papers published in top venues, six are pursuing a Ph.D. in artificial intelligence or theoretical computer science and two more are pursuing a Ph.D. in microeconomics, all at top departments. In total I have advised, or co-advised nineteen senior theses, seven in computer science, six in computer science and economics, four in applied mathematics, one in computer science and mathematics, and one in computer science and psychology. I have also supervised three teams of undergraduate students in their participation in the Trading Agent Competition (TAC). This is an international competition, in which teams design automated software agents that compete with each other in a simulated electronic supply chain. Each year that we competed we had one of the few, and perhaps the only, all-undergraduate team. TAC provides a great opportunity to get students engaged in hands-on research in AI, while also introducing them to the research community by allowing them to attend the competitions which are collocated each year with a leading AI conference.

**Future Plans.** I will continue to advise students that cross boundaries and bring different perspectives and interests. My plan is to advise a slightly smaller group, typically consisting of 4-6 graduate students, 1-3 undergraduate students and possibly a postdoc or other visitor, and also to include students that I co-advice in the ITM/STM program with HBS. I believe that a group of this size will provide a very active research program at the intersection between computer science and economics and ensure continuing impact for my research and the research of the students with whom I am so fortunate to work.