Teaching Statement

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January 1, 2009

It is through the act of teaching that one really learns. Teaching new material forces us to learn because it requires that we understand key concepts, distill our insights, and understand the context and structure of the space. On the other hand, teaching familiar material lets us revisit long-held views with fresh eyes, the passage of time, and the benefit of hindsight. It is for these two reasons, and a strong desire to deeply impact students, that I have sought out many teaching opportunities at both the undergraduate and graduate levels. I have taught ten times (eight quarters at Ohio State and two semesters of UC Berkeley), conceived and helped design several of the courses I taught, and raised more than $53,000 in equipment grants from industry to support these efforts.

Teaching Philosophy

Aristotle wrote, “for the things we have to learn before we can do them, we learn by doing them.” This philosophy is particularly relevant today because the skills and artifacts of our modern world are vastly more complex than were the ones of the ancient world in which these words were first written. I believe that today, more than ever, the way to teach operating systems is to have students design and implement a small operating system; the way to teach networking is to have students design and implement protocols; and the way to teach chip design is to have students design and tape out an integrated circuit.

The learn by doing approach is the keystone of my teaching philosophy because of its emphasis on concrete, practical knowledge. I believe that when students learn by doing, they acquire an intuitive understanding of a subject that can then be generalized. However, we often teach things in reverse, beginning with rather pure and abstract generalities instead of grounded and concrete specifics. Herman Witkin’s work on field dependence-independence shows that while field independent (abstract) thinkers can learn when concrete ideas are presented in the context of a larger framework, the opposite is often not true: field dependent learners do not process ambiguous information very well without an external frame of reference because they usually do not impose their own structure onto the material. In other words, field independent learners reign in the chaos themselves while field dependent learners let chaos reign unless an external order is imposed.

Bridging the field dependence-independence gap between students is possible by keeping both the overall framework, and the specific topic of study, in perspective at all times. In talks, for example, I like to motivate the subject with a compelling application, then present an overall outline for the talk, then explore each subtopic in detail, but return to the outline between subtopics. I follow a similar technique when teaching board design: I start with the overall design flow, then highlight the individual steps, next discuss the artifacts that each step produces, and only then detail the activities within each step. I have used a similar approach to teach networking and operating system concepts, circuit design, and software engineering.

Students should “teach” as part of the learning process. When students teach – when they have to learn a topic well enough to stand in front of their peers and present it – students achieve a high level of preparation, they learn key concepts thoroughly, and their fear of public speaking begins to wane. At the undergraduate level, I ask students to present their work to the class. At the graduate level, I expect students to regularly present papers to their peers.
Evaluation is the capstone of our learning process. Although one learns by doing, teaching, and practicing, Bloom’s Taxonomy of intellectual behavior places evaluation at the top of the cognitive pyramid. I certainly believe my own writing improved once I started reviewing papers, my own understanding of a subject improved after I started grading exams, and my perception of a successful graduate career sharpened after I started attending job talks. Students should be given the chance to evaluate the work of others through research, teaching, and service channels. In research, students should critically evaluate related work and referee conference and journal submissions. In the classroom, students should evaluate each others’ work and attempt to “break” or outperform each others’ implementations. The more academically-minded students should seek out teaching assignments with grading experience and participate in graduate admissions and faculty hiring.

Finally, I believe in motivating students with challenging goals—a kind of “grand challenge” suited to the classroom. For example, in a freshman capstone course I helped to conceive and implement at Ohio State, we ask teams of four to plan, design, build, program, test, and redesign a fully autonomous mobile robot in just nine weeks. The robots (numbering some fifty or more) compete in a head-to-head competition, which is a tall order for most first year engineering students. Motivated by high expectations, encouraged by the teaching staff, and supported by their peers, the great majority of students persevere and by the end of the term, every team fields a working robot. By challenging students, helping get their competitive juices flowing, and ultimately helping them succeed, we can engender a fearless, achievement-oriented culture that will ultimately serve them, their employers, and their communities well.

TEACHING AND ADVISING EXPERIENCE

During a visit to MIT as an undergraduate, I discovered MIT’s 2.70 and 6.270 integrated design courses. Inspired by the excitement for learning that these courses generated, I sought and obtained over $53,000 of corporate equipment grants from Motorola, Panasonic, Sharp, AMP, and others to support a similar course at Ohio State. I worked with EE faculty to help create the course plan and assisted students with sensor selection, circuit design, drivetrain design, programming, and project planning. This course eventually found a permanent home in the Ohio State University Fundamentals of Engineering Honors program for first year students, where I continued to teach the course as a undergraduate teaching assistant through my senior year in college.

Today, this course impacts a quarter of incoming engineering students each year and is a perennial hit among students, parents, and employers; its annual competition draws thousands of people. Enrollment has grown tenfold from 30 students the first year to over 300 students in 2008. The program serves as a powerful recruiting tool that draws talented high school students to Ohio State. Compared to a control group, program participants consistently demonstrate higher retention, reduced time to declaring a major, higher grade point average, a greater rate of co-op and internship participation, increased participation in extra-curricular activities, higher rates of graduation, shorter time to graduation, and greater participation in graduate education. See: http://feh.osu.edu

The original design course was named a “University Success Story” by Motorola and I received Ohio State’s Presidential Leadership Citation “In recognition of Outstanding Leadership and Service to The Ohio State University and for Demonstrating Exceptional Dedication, Creativity, and Commitment to Quality” for my contributions. I believe this experience illustrates just how dramatic an impact a carefully-designed course following the philosophy outlined above can have on a large number of students.

In the fall of 2005, my advisor David Culler took industrial leave to start a company. Most of the senior graduate students in my research group left to join David or graduated and went to industry or academia while, back at Berkeley, three first year graduate students interested in sensor networks arrived. I became quite concerned that the “brain drain” would affect the new students and the group’s research momentum. I addressed the first concern by mentoring the three students on a range of topics large and small. This mentoring led to one NSF Fellowship, one NSF honorable mention, and one NDSEG award. It also led to a collaboration that has yielded nine co-authored papers between 2006 and 2008, and my first real experience with graduate advising.
I addressed the second concern by co-organizing and teaching a graduate seminar on sensor actuator networks in Fall 2005 with David Chu, a fellow second year student, under guidance of our advisors, David Culler and Joe Hellerstein. I developed the course structure, selected many of the readings, helped groups formulate and carry out their research projects, and recruited many of the guest speakers. The guests included Sam Madden (MIT), Ramesh Govindan (USC), Deepak Ganesan (UMass), Jose Gutierrez (Eaton Corp), Feng Zhao (Microsoft Research), Carlos Guestrin (CMU), David Gay (Intel Research), Tarek Abdelzaher (UIUC), Joe Polastre (Moteiv Corporation), and Phil Levis (Stanford). See: http://www.cs.berkeley.edu/~prabal/teaching/cs294-11-f05/

**Future Plans**

I plan to teach undergraduate and graduate classes, advise four to six students, create one or two new graduate seminars, and engage in a handful of broader outreach activities.

**Teaching.** My coursework and research across the EECS spectrum has given me a broad view of the discipline, an appreciation for the key ideas of many sub-disciplines, and how the sub-disciplines relate to each other. I will leverage this education to teach traditional undergraduate computer science courses in systems, networking, and architecture, as well as traditional electrical engineering courses in circuits and digital systems, and especially courses with a laboratory aspect.

At the graduate level, I plan to teach advanced operating systems, networking, and distributed systems. I believe the ultimate goal of graduate coursework is to teach students how to do research by evaluating prior work and undertaking a significant and independent research project of each student’s own choosing. For graduate courses, a combination of paper readings, written paper evaluations, in-depth classroom discussion, conference-quality term projects, and a project presentations require students to operate at the highest cognitive levels – synthesis and evaluation.

**Advising.** The highest goal of graduate advising is to teach students the art of selecting problems and the science of evaluating solutions. Mentoring graduate students is one of the most important and enjoyable aspects of being a professor but choosing which students to advise requires great care. I plan to spend my first year teaching graduate courses, working with the incoming class of students, and exploring deeper research problems with a few of the students who share my research interests. I plan to meet with these students at least weekly and perhaps more often if the situation demands, for example, before a paper deadline or while brainstorming new research directions.

Although the advisor-advisee relationship is an important one, many students learn more from their interactions with peers than they do from their advisor. As an advisor, my goal will be to facilitate this important learning process by choosing research projects that are big enough to support multiple students but small enough to complete, and encouraging students to collaborate with their peers on these projects. Over time, I will also encourage more senior graduate students to mentor more junior ones, as well as undergraduates interested in research.

**Course Development.** In the short term, I will offer graduate seminars on one or more contemporary topics in computer science focused on wireless networking, mobile computing, green energy, or sensor networks. These courses will expose students to seminal work, like Mark Weiser’s visionary papers, but also let them learn about recent developments in each field. Like traditional graduate courses, these advanced topics seminars will be reading-intensive and project-based, but unlike more traditional courses, much greater student participation will be expected through student presentations and classroom discussion. In the longer term, I plan to adapt existing introductory undergraduate courses, or develop new ones, that broadly expose students to the discipline but are grounded in contemporary topics and platforms, including mobile or web application development, mobile robotics, or wireless sensor networks.

**Community Outreach.** As beneficiaries of public funds, I believe academic researchers have an obligation to contribute more broadly to society through a diverse set of outreach activities. These activities might include developing and disseminating teaching materials, helping judge high school science fairs, giving keynote addresses outside of one’s home research community, helping industry leverage research results, raising the visibility of computer science in the local community, or encouraging high school students to spend a summer in a university research lab.