Teaching Statement --- Daniel S. Drew

In a world with an increasing demand for engaged and active scientists and engineers, it is vital that we give students the tools they need while kindling the passion that got them there in the first place. I know that a single class can be enough to change someones relationship to learning, and a single mentor can easily change a life; these are tremendous opportunities for a professor to make a real impact on the world, regardless of any research agenda. I have learned a lot from being a student assistant for two upper-division/graduate level classes and two introductory classes, from mentoring both undergraduates and junior graduate students, and from the exceptional mentors I have had along my own path in graduate school. Drawing on my experience, I can summarize my current approach to teaching and mentorship in three core statements of practice:

> Experiential learning through collaborative projects merging design and practice, as well as applying knowledge in laboratory sections and implementation-based assignments, is a core component of any curriculum.
>
> Enthusiastically emphasizing the broader impacts as well as creative facets of engineering is important both as a pedagogical tool and as a way to increase access to opportunities for all students.
>
> It is vital to teach students and junior researchers to become both independent investigators and effective communicators, tying the two together by showing them how to weave a narrative thread through subject material.

training students as investigators

The interdisciplinary nature of the problems facing the modern world leads to an incredible amount of required domain knowledge. Luckily, there is also unprecedented access to tools for searching for and applying that knowledge; together, this means that *training students as investigators is more important than ever before*[1]. It is vital that an engineer, given a problem, can identify challenges along the critical path, make the correct simplifying assumptions to focus their effort, and collate the required information for finding a solution. Although a solid grounding in domain fundamentals is important for all three of these tasks, even more important is cultivating the mindset required to effectively practice this kind of problem solving [2]. In my teaching and mentorship I emphasize breaking down a problem into manageable parts, setting realistic and useful milestones along the path to a solution, and developing methods to objectively evaluate and compare those solutions.

Modern engineering practice is a creative process. Some programs now incorporate formal design (user-centered and otherwise) into their curriculum; both taking and helping to teach one of these courses has led me to believe that it may be the critical piece necessary to push students towards innovation and impact. I believe that *a project where a student feels like they are applying their knowledge to solve a real-world need can lead to the kind of passion that creates life-long learners and innovators.* My experience taking Interactive Device Design at Berkeley exposed me to design-focused project work and fundamentally changed the course of my graduate school career. I was excited enough about the course curriculum to help teach it twice; I found it immensely rewarding to see students gain experience and confidence working across traditional field boundaries on their projects. During the Summer term offering, where students were pulled from outside the university and outside traditional departments, I had a Music Theory major go from almost zero electronics and prototyping experience to building a fully-featured interactive device. Students left the class eager to either expand on their project or solve other problems they had uncovered along the way, and they now believed they had the skills required to do so.

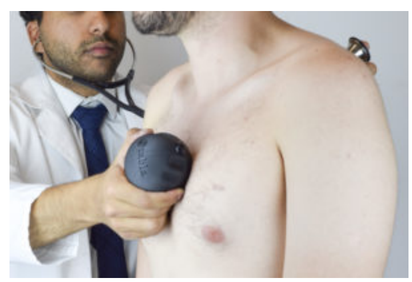

Figure 1: Tabla, a device for diagnosing pneumonia using acoustic actuators and integrated sensors, was a final design project in the Fall 2016 Interactive Device Design class I helped teach. It later won the 2017 Big Ideas at Berkeley competition.

increasing access with mentorship and instruction

I think that one of the best ways we can increase access to higher education is through outspoken communication of a passion for research and learning. At its core, I think that doing good science is about using your imagination to solve problems. The more we can reinforce the notion that learning and participation in research is not merely a means to an end but instead an active way to nourish our imagination, the better we can convey the value of

[1] *Educating the engineer of 2020: Adapting engineering education to the new century.* National Academy of Engineering, 2005
[2] *How people learn: Brain, mind, experience, and school: Expanded edition.* National Research Council, 2000.

a diverse education. Research opportunities, and a STEM education, should be radically inclusive. The first step is to create opportunities for those that may not have them otherwise; the next is to reach out with open arms to those who may not be aware of the opportunities they *do* have. As a first generation college student, I only really became interested in graduate school after a summer REU program at MIT showed me what it actually was. I have since participated in a number of REU student panels and admissions boards, as well as mentoring both REU students and students recruited through university-wide channels. Casting a wide net is the best policy — the biggest shame of all would be a student never knowing the opportunity existed in the first place. I look forward to making undergraduate research, and helping my graduate students to become better mentors of those students, a critical component of my group culture.

As we strive to increase access, we may actually compound the growing issue of enormous class sizes at the introductory level. Working as a graduate student instructor for Berkeley's EE16A: Designing Information Devices and Systems was a great opportunity to experience a recently remade core EECS class, learn about the administration of a large (almost 1000 student) class, and to help shape the introductory experience for many students just starting their degrees. The depth of the homework assignments was perfect for pushing students towards that "investigator" role that they may not have had to take on before college. Lab sections let them apply their knowledge to real-world problems; students got a sense for the importance of linear algebra when cross correlation allowed them to implement and test spatial audio noise cancelling. I got a behind-the-scenes look at the incredible amount of administrative overhead and necessary organization required to effectively engage with such a large number of students. I have learned how to leverage online tools, as well as the energy of student instructors, to make it a manageable task.

Figure 2: Rapidly increasing EECS class enrollment leads to crowded conditions, even in auditoriums repurposed as classrooms; teaching these classes effectively is a unique challenge. Photo of CS61A courtesy of The Daily Cal.

`engaging students and teaching effective communication as a skill`

One of the challenges with the large EE16A class was that it is required for both electrical engineering and computer science students, while about a third of the class curriculum is based on electronic circuits that the latter group "won't need again". I learned that, besides demonstrating the real-world value of the material, *the best way to motivate students to engage in the learning process may be to effectively communicate your own excitement for the subject.* My student teaching reviews more often than not mention enthusiasm and a genuine sense of excitement as being positive experiences, regardless of the rest of the content. Communication also extends beyond the classroom and laboratory to affect the potential our research has for making a broader impact. I have begun to practice my own skills at general audience communication, recently winning 2$^{\text{nd}}$ place at the UC Berkeley Grad Slam, a research presentation competition aimed at engaging the public. In a world where distrust of the academy and dissemination of misinformation seem to be growing, I think that it is increasingly important to be able to make the leap from presenting to a group of in-discipline peers to presentations aimed at educating the public, and we should be training next-generation scientists with this in mind from the beginning.

Effective communication of research involves telling a story. In my mentorship of junior graduate students, one of the skills I try to transfer is the ability to put their work into a narrative context that can both capture the imagination as well as convey the challenges that have been overcome. Consistently evaluating your agenda along the lines of fitting it into a compelling story helps to define the most interesting research problems, focus efforts on the parts that matter, and build a group of engaged collaborators. There are also more mechanical fundamentals to this communication style: effective use of images, rhetorical methods, and even slide design are all important parts of impactful research that *can* be taught and learned. In meetings I will ask students to concisely frame their work before diving into it, to focus on planning the message and flow of their presentation or text before getting started, and to always be able to answer *why* they are doing something, not just what. My collaboration with junior graduate students and undergraduates has ultimately led to a number of publications[3] , but more importantly I have been able to observe with satisfaction the effects of my efforts propagate out to their later work. It is extremely gratifying to see your methods being applied in new contexts, or to hear your advice echoed to a new student in another person's voice.

[3]Zoll, R. S.**U**, Schindler, C., Massey T. L., Drew, D.S., Maharbiz, M.M., & Pister, K.S. MNMC 2018;
Lambert, N.O.**J**, Drew, D.S., Yaconelli, J.**U**, Calandra, R., Levine, S., & Pister, K.S. ICRA 2019 *Under Review*;
McGrath, W., Drew, D.S., Warner, J.**J**, Kazemitabaar, M.**J**, Karchemsky, M.**U**, Mellis, D., & Hartmann, B. UIST 2017.
(U = Undergraduate, J = First-year Graduate Student)

proposed courses

The courses I look forward to teaching are inherently interdisciplinary as well as practice- and communications-focused. I think they can be designed and scaled, as needed, to pull students from across numerous departments and across multiple levels of experience. They include:

Introduction to MEMS

A course covering the underlying physics, fabrication, and design of micro-electromechanical systems. An emphasis is placed on hand analysis as a tool for design of devices and their supporting systems. Case studies will break down some of the historically significant advances and devices in MEMS that have led to the maturation of the field. A final paper will explore the potential to improve performance in a student-selected domain through miniaturization.

Target students: Upper-division undergraduates and graduate students in Electrical Engineering and Mechanical Engineering.

User-centered Design of Interactive Systems

By merging Maker-style electronic and physical prototyping techniques with a user-centered design process, students will develop the skills required to design, prototype, and fabricate cyberphysical systems with broad impact. An initial series of small (one- or two-week) project assignments will lay the foundation for a team based design project that takes groups through an accelerated product design cycle.

Target students: Upper-division undergraduates and graduate students in Electrical Engineering, Computer Science, and Mechanical Engineering. Other departments according to prior experience of applicant students.

Interactive Mechatronics

A project-based course focused on prototyping mechatronic systems. Emphasis will be placed on systems meant to be used alongside humans in the interdisciplinary areas of automation, haptics, and assistive robotics. Rapid ideation and iteration practices will be taught alongside the fundamentals of control theory and practical electronics; there will also be a significant component of need-finding and system planning prior to implementations.

Target students: Upper division undergraduate students in Electrical Engineering, Computer Science, and Mechanical Engineering.

Micro- and Swarm- robotics Seminar

A survey of current research literature in this emerging, interdisciplinary field. Students will read up to four papers per week and submit written responses to prompts online. Class discussion will focus on subfield topics (e.g. "actuation", "human-swarm interaction"), with appropriately themed concurrent reading assignments. Students teams will work to quantify and visualize comparisons between methodologies in the literature as a tool for identifying potentially interesting research problems and directions.

Target students: Primarily graduate students in any relevant department, open to upper-division undergraduates in case of a recommendation.