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GRAD ED SPOTLIGHT

# Learning to teach

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While many intellectually and financially rewarding engineering jobs require just a bachelor's degree, graduate education is the key to careers in research and university teaching. Many graduate students—perhaps you are one of them—pursue doctoral studies because they are considering academic careers. Some students are passionate about teaching from the beginning, while others want to find out if they enjoy it in order to decide whether to seek work in industry or in academia.

Surprisingly, even though graduate school is the only path to university teaching, it is not always easy to get teaching experience and mentoring while you are there. Some doctoral programs require their students to serve as teaching assistants, while others do not. In either case, students and faculty alike often view teaching as a distraction from research, to be pursued only if research funding is tight. Paradoxically, the students with the easiest access to research funding may thus have the most difficult time finding opportunities to teach.

While doctoral programs differ from university to university and department to department, a doctoral student's main task is to produce original research and write it up as a dissertation under the mentorship of a committee of faculty members. These faculty members will have earned their positions at the university on the strength of their research. Many of them will be experienced at supervising student researchers and advising students embarking on research-oriented careers in academia and industry.

These same mentors, however, are much less likely to be passionate about teaching. In their jobs, there is little reward for maximizing their teaching performance—the rewards are in producing publications and winning grants. Furthermore, their view of academia is



Digital Object Identifier 10.1109/MPOT.2010.937461

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usually centered on research institutions like their own, and they may not know how to best prepare their students for work at institutions with more emphasis on teaching.

This article will discuss the different teaching and mentoring requirements of the types of jobs that Ph.D. students in engineering usually seek. It will also provide advice for Ph.D. students seeking teaching experience that prepares them for a variety of jobs without sacrificing their research.

A disclaimer: this article is, unfortunately, U.S.-centric in its perspective. The challenge every teacher faces is to contextualize the material specifically for the group of students in front of them—with their unique cultural and academic backgrounds, their academic abilities and difficulties. Rather than attempt to generalize across cultures and systems of higher education, I have chosen to focus on what I know. However, I hope to hear from readers who can provide international perspective on the material presented here.

## Teaching jobs: University and beyond

While teaching skills are valuable in almost any job, different institutions place different types of demands on their employees. Graduate students are usually most familiar with research institutions, in which professors may teach one or two courses a semester and can use research money to lower their teaching loads further. At these institutions, professors pride themselves on teaching up-to-date and relevant content in their areas of specialty. However, they must also be ruthlessly efficient with their time because of the demands of research, which make it difficult to get to know students well or to understand how well students are processing information from week to week.

Universities that don't grant Ph.D. degrees tend to place more emphasis on teaching, but the details vary by institution. At one end of the spectrum—community colleges—professors may teach five or six courses per semester. Because their classes are usually small by research university standards, they do get to know their undergraduate students, but the sheer number of courses means that they must be equally ruthlessly efficient with their teaching time for any given class. A more typical load at a teaching institution is two to four courses per semester, and the difficulty

of this teaching load is all in the details—does it consist of multiple sections of the same course or courses that are truly separate? How many of these courses has the instructor taught before? How many students are in each course? Are student assistants or graders available? Different institutions and departments will have different answers to these questions.

What if you're not interested in academia at all? While an industry job will allow you to spend your evenings and weekends unencumbered by stacks of

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exams to grade, don't think that you will escape other aspects of teaching so easily! Industrial research labs are flooded with doctoral students every summer to help with research projects, and many industrial researchers enter long-term collaborations with doctoral students. More broadly, as you gain experience in any job, you will be asked to train and mentor people who are less experienced than you. This process, which also involves assessing people's current understanding and figuring out how to, is another form of teaching. Finally, as your career evolves, you may find yourself teaching part time or after you retire.

## Teaching skills

What skills does an engineering teacher need? Many people immediately think of lecturing—the ability to present course material crisply and clearly in a way that engages a room full of sleepy students. However, lecturing is just the tip of the iceberg, the most visible part of a large and complicated skill set. To be a well-rounded teacher, you will want to develop your skills in four interrelated areas: presentation, course design, assessment, and interpersonal communication.

### Presentation

Since presenting information is the most visible part of a teacher's job, let's start there. If merely thinking about

standing in front of a group of students makes you shudder, you've probably already decided that teaching isn't for you. However, the skills of explaining concepts clearly and accessibly, as well as becoming a dynamic speaker, are hardly limited to the classroom in their usefulness. They're well worth developing regardless of where you end up. Teaching allows you to practice these skills and forces you to get over your perfectionism—if you have to stand up and present material one or more times a week, in addition to doing your research, you will not always be able to be as prepared as you would like. You will learn to speak more extemporaneously and prepare more efficiently. In addition, because you will have extensive contact with your students throughout the semester, you will be able to adapt future lectures based on where your previous presentations succeeded and where they fell short.

On the other hand, if you love the idea of presenting a beautiful exposition of the course material to an audience of rapt students entranced with your brilliance, be careful! Improving your teaching involves more than finely honing your presentation skills, and it's easy to spend a great deal of time going down that path. Good teaching involves making sure that the material connects with the students and adjusting it based on their real-time feedback. Spending too much time on the material in isolation can be time-consuming, causing you to neglect your research without seeing your effort rewarded by increased student performance.

It's also important to recognize that lecturing, though it's a very popular teaching method in large engineering classes, isn't the only way of presenting information. If you've taken graduate seminars, you may have seen another possible method: student-led discussion. By taking these classes, you can practice leading a discussion while you're still a student. Pay attention to different professors' techniques for facilitating discussion and the different methods your classmates use to engage you when they lead discussions. Experiment with active learning techniques—having students practice concepts and demonstrate their learning while in class.

### Course design

Many important decisions are made before the semester begins. The pace of the course, the order in which topics are

covered, and your policies on a host of issues from grading to late work to attendance, have the power to motivate or frustrate students—and you. Planning the course schedule is easier if you first decide the *learning outcomes* of the course—what do you want students to learn, and how will you know that they have learned it? From there, creating the syllabus and the course policies can be like a jigsaw puzzle. The schedule, assignments, and policies of the course are all interrelated, and it takes time and experience to carefully plan them out.

### Assessment

In a typical engineering class, student grades may be assigned based on a combination of exams, problem sets, and projects. These assessments, if well crafted, should be educational for the student and should allow you to determine if the student has succeeded in learning the material. Good teaching involves creating assessments that build the students' skills as well as testing them. Assessments should also be fair—students should understand that their grades are not assigned capriciously or arbitrarily.

Good teaching also involves using assessments as feedback to guide instruction. The quality of student work can tell you a lot about how the class is going and what you have taught well and poorly. Grading may seem menial, but it is the only way to understand how the class is doing and adjust instruction as necessary.

Finally, higher-education accreditation agencies view learning outcomes and assessment as essential aspects of courses and programs. Universities spend a great deal of time and money ensuring regional accreditation for the entire institution, and many engineering departments follow a similar process to obtain discipline-specific accreditation from ABET. Designing your assessments carefully and being fluent in assessment-speak will endear you greatly to your colleagues who are involved in these efforts.

### Interpersonal communication

The notorious stereotype of engineers is that we are introverts, but teaching depends on the human connection. Part of teaching involves bridging the gap between the introverted traits that make successful engineers and the extroverted traits that make successful teachers. Fortunately, there are specific skills that students can concentrate on developing.

The first is classroom management, which overlaps to some extent with the

ability to lecture. Every teacher must develop policies and techniques for holding the attention of students who may be sleepy, overworked, bored, or worse, fiddling with some addictive electronic device. How you set and enforce boundaries is entirely personal—some teachers feel most comfortable with sweeping policies, while others choose their battles carefully. Your attitude to the students also affects their behavior—students are quick to rebel against teachers they view as contemptuous or condescending (or, some would say, vulnerable).

The next is your interactions with students on an individual basis. Being deliberately unapproachable saves time,

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since fewer students will dare speak to you, but it's hardly a way to serve your students. Finding the best balance between being encouraging and rigorous is something every professor has to figure out for every group of students. Furthermore, good teaching requires being supportive of students' diversity—whether that means first-generation college students, students with disabilities, students from different cultures, or students from groups that have traditionally been underrepresented in engineering. Since the higher education system presented barriers to these students for many years, instructors should want to avoid further compounding these difficulties.

Finally, instruction often includes working as part of a course staff—a team of instructors and student assistants. Ultimately, professors are responsible for managing this team in a way that allows all members to thrive and best serve the students in the course.

### What you can do

Teaching assistantships are one obvious and structured way to get teaching experience, but they're not the only way. Depending on how advanced you are in school and the amount of time you have available for teaching, there are several possible options.

### Reading

Given the research-oriented nature of graduate school, sometimes the best teaching advice can be found online or in books. Reading about teaching can also sensitize you to the wide differences in teaching needs and practices across different types of institutions. Some books and Web sites that I've found helpful are listed at the end of this article. However, reading is no substitute for experience, so don't stop there!

### Grading

At research institutions, professors and TAs will generally grade exams, but homework assignments and labs are often delegated to part-time graders who are otherwise unconnected with the course. You can take advantage of this situation by applying for a grading job, which typically doesn't require the layers of bureaucratic approval (and advisorial permission) that a teaching assistantship does. You'll quickly learn to grade efficiently and consistently, and you'll also develop an eye for the common misconceptions held by students.

### Tutoring

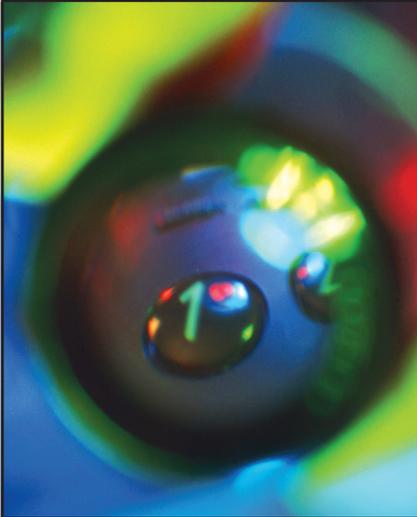
Tutoring is one of the most worthwhile ways to earn a little bit of extra money as an undergraduate and beginning graduate student. It's also likely to be the only time in your teaching career that you'll be able to dedicate yourself to helping an individual student overcome the challenges of a course. You'll solidify your knowledge of the subject matter by essentially repeating the course, and you'll learn to put yourself in a student's shoes and figure out how to connect that student with the concepts at hand. Finally, if you hold an official tutoring position through the university, you should let the course staff know that you are available to help students. This extra connection can help professors and teaching assistants get to know you, and they can end up being a valuable source of recommendation letters and other opportunities.

### Teaching assistantships

Graduate teaching assistantships are typically paid positions that give you a tuition waiver and a modest stipend; undergraduate assistantships vary more widely. In small classes taught by hands-on professors, your duties may simply involve answering student e-mail and taking care of clerical items. More typically, you might also update the course Web site, conduct weekly review sessions,

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Whether you want to spend your life in front of a classroom or leave the university far behind when you graduate, many of the skills you learn in teaching will be useful in other aspects of your career.

and write homework problems and exam questions. At the hands-off extreme, some professors, delegate almost everything except lecturing to the TAs. Whether this is a burden or an opportunity depends on your level of interest in teaching.

TA jobs give you a chance to experience the class as both instructor and student. You will come to understand how the professor approaches the class and the reasons for the policies and practices that have been set up. On the other hand, you will also hear from the students—since they will probably perceive you as more approachable than the professor, they are more likely to tell you what they think of how the class is going.

### Instructorships

Some institutions allow graduate students to actually teach their own classes, often over the summer. This experience will be immensely valuable if you intend to apply to teaching-intensive institutions with heavy course loads; the hiring committee will want to know that you have planned and taught courses on your own before throwing you into that work environment. However, teaching a course on your own is likely to consume most of your time for that semester, so tread carefully and consult your advisor.

### Mentoring

Mentoring is likely to be a part of your job whether you end up in industry, at a research institution, at a teaching institution, or somewhere else altogether. Therefore, you should definitely seek out opportunities to practice mentoring and supervising others in graduate school. As you progress through graduate school, you are likely to unofficially mentor junior graduate students who help you with your projects as a way to gain their own footing. You should also seek official mentoring opportunities, such as supervising undergraduate researchers, lab visitors, or even high school students. The experience will not only make your job applications more

impressive and teach you a valuable skill, but it can help you progress in your research as well.

Whether you want to spend your life in front of a classroom or leave the university far behind when you graduate, many of the skills you learn in teaching will be useful in other aspects of your career. By seizing small opportunities to teach and reflecting on your own and your professors' practices, you can improve your skills and develop a coherent perspective on teaching without necessarily dedicating your life to it in graduate school. This combination of experience and insight will enable you to make informed career choices and increase prospective academic employers' confidence that you will be able to manage the demands of the job from the beginning.

### Read more about it

Although teaching experience is valuable, you don't have to learn everything the hard way. Reading up on educational practices, both within your field and in general, is a way to broaden your perspective and avoid some of the traps that inexperienced teachers fall into. The resources below illuminate different aspects of university teaching:

- R. Boice, *Advice for New Faculty Members*. Boston, MA: Allyn & Bacon, 2000.
- Chronicle of higher education online forums, especially "in the classroom" [Online]. Available: <http://www.chronicle.com/forums>
- R. Felder. Resources in science and engineering education [Online]. Available: <http://www4.ncsu.edu/unity/lockers/users/f/felder/public/>
- M. Guzdial. Computing education blog [Online]. Available: <http://computing.ed.wordpress.com>
- W. McKeachie and M. Svnicki, *McKeachie's Teaching Tips: Strategies, Research, and Theory for College and University Teachers*. Belmont, CA: Wadsworth, 2005.

### About the author

Suzanne Rivoire ([rivoire@gmail.com](mailto:rivoire@gmail.com)) is an assistant professor of computer science at Sonoma State University in Rohnert Park, California. She holds an M.S. and a Ph.D. in electrical engineering from Stanford University and a B.S. in electrical engineering from the University of Texas at Austin. She is an associate editor for the *IEEE Potentials* editorial board and previously served as the magazine's editor-in-chief. Her research interests are computer science education, computer architecture, and energy-efficient computing.