the role of the lab TA

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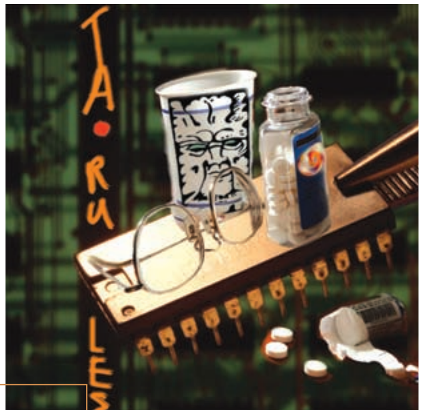
you set the tone



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So, you just arrived at your new university for grad school. You aren't quite sure what to do or what is expected of you, especially as a teaching assistant (TA).

While preparing a talk to beginning lab TAs a while ago, I thought back to being a TA myself. I remembered how the students weren't as excited about the lab part of their courses as I would have hoped. How dissatisfied many were about how much work there was for such few credits. My goal here is to help you to make those lab experiences the best that they can be for the undergraduates, and for yourself.

My perspective on labs comes first from my experiences as an undergraduate. I remember being excited when lessons taught in class came to life on the bench equipment. Today, I find that my understanding of many of the basic concepts in Electrical Engineering were formed by those experiences.

Throughout I will share with you certain aphorisms. The first is, "you don't really understand something unless you can explain it well." Saying, "I know what I need to explain to you, but I don't know how to say it," is just fooling yourself. Whenever I could not readily explain something to a student, I later realized that I did not "own" the material; it was still fuzzy in my mind. When forced to explain it, the concepts became more crystallized. I have learned that *there is no better way to learn a topic than to teach it.* You have that opportunity now as a TA, and I guarantee that you will come away from the experience more mature, more technically capable, more focused on your career goals, and more self-fulfilled. Some of you may feel stuck with teaching a lab section, but I am here to tell you that it can be a blessing. Treat it as such, and you and your students will be much better off for it.

As the TA

We now come, then, to the goals of this article: to help you see the forest for the trees; to appreciate the vital importance of the laboratory experience; to enjoy the time spent in lab; to help your students get the most out of it. You are the leader now, the mature professional who has navigated the rite of passage of a Bachelor's degree and *chosen* to go to graduate school. If you were not successful as an undergrad, you wouldn't be here, and *your students know that.* This is your chance to be an engineer role model.

In this sense, it is important for you to appreciate the role of the lab experience in the education and development of the undergraduate. First, keep in mind that you will probably, at times, be frustrated by what you perceive to be imperfect lab write-ups and inadequate equipment. Every lab course is different, and there are innumerable hidden constraints related to available funds, staff, technical expertise in your department, space and more. Someday you may be in a position to develop a lab the way you want. In the mean time, helping to explain obscure sections of the assignment, and pestering the departmental technician until things are fixed is about all you can do. The students will recognize how hard you try.

Once past these hurdles, enjoy being in control. This is best accomplished by *being prepared*—knowing the activities inside and out, and expertly answering the students' questions. This preparation is also the first step in the process of gaining self confidence for being a manager in a large corporation, having your own business, being a professor and advising graduate students, or heading up a major engineering project. (The people who do these things in your generation will likely have been TAs.)

The professor in charge of the course will rely on you to handle many aspects of the lab, including grading, so you will have a tangible effect on the students. You also should be acutely aware of any safety issues in the lab. Ask your professor about this specifically. Regard the nuts and bolts of running the lab smoothly and fairly as a true responsibility. The students will form attitudes about their college experience and their future careers partly based on how you act toward them and how you outwardly feel about your own presence in the lab.

Do the students and the faculty expect you to be an instant expert on the theory, equipment, and experimental techniques that you will need to teach the lab? Actually, no. The students have a keen knack, however, for seeing through the bluffs that necessarily go along with poor preparation. But everyone respects an honest effort even when coupled with imperfect knowledge. And…you can *ask your professor!* That's right, just walk up to your professor and admit you might not know something. You won't be instantly branded as ignorant. You will, in fact, learn something and earn the professor's respect. Most faculty welcome questions and have a more positive view of a class in which questions are asked and students show up to their office hours. You will find this out yourself

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after you sit in your recitation section or your office hours waiting futilely for your students to stop by with their questions—especially when you know they really need help with the material.

The undergraduate experience

As a TA, you may wonder what is the role of the undergraduate laboratory experience in educating engineers, especially since we tend to associate "experiments" with scientists. To address this, I refer to an aphorism that is becoming more blurred with time: "Scientists answer questions, engineers solve problems."

Some engineers like to develop things and solve problems because it makes the world a better place. Some scientists like to explore the world out of curiosity. Great laboratory experiments were involved in nearly every major scientific discovery, and it has often been engineering experimentalists that have made these historic breakthroughs. Technological advances cannot happen without *everyone* in the process being familiar with laboratory skills and practices.

So, what is going on in a typical engineering educational laboratory? It is probably more correct to label these activities as "controlled assignments" rather than as "experiments," write the authors in "Assessment of Undergraduate Electrical Engineering Laboratory Studies." Because often the lab activities of the students are more closely regulated during the course of the session and there is relatively little room for creativity. Controlled assignments, of course, are the subject of nearly every first year lab class in chemistry and physics as well. There is definitely a place for this. Although it is not politically correct to stifle "individualism," it is still vitally important for students to learn laboratory safety, correct use of instrumentation, correct recording procedures, and techniques for assuring accuracy in measurements.

In undergraduate labs, the philosophy ranges from controlled assignments to experimental investigations. Where students are encouraged to play, and results can be more open-ended, all kinds of challenges for grading and evaluation arise. But it is a much more exciting experience for the instructors and the students.

Finally, many schools offer opportunities for projects that are nearly totally open-ended. Many of you have had the opportunity to be involved in this sort of activity. You may find yourself involved in this kind of a laboratory experience with Juniors or Seniors, but increasingly at the Freshmen level as well. Being a TA in this sort of environment offers unique challenges, and you will want to communicate more closely with your professor to learn what is expected of you. Since each situation will be very different, I won't say much about that here.

But, it is far more likely that you will be involved with the controlled laboratory setting. Some students respond well to this sort of structure, feeling more secure with the lab reports. Others may become bored with it. Even while performing the required "experiment," some students have an urge to try different things and challenge the parameter space until something gets interesting and requires an explanation.

I hope that you will foster that kind of inquisitiveness that may be lying dormant in some students. Encourage the students to play during the lab and have fun. Encourage small forays into independent thought and experimentation. If you succeed, the students will benefit by gaining self-confidence and a better understanding.

Now, what I see as the real purpose of the laboratory, from a developmental standpoint rather than a technical one (by that I mean learning about equipment, writing reports, etc.) is partly one of learning through touching and doing as well as one of visualization. First, material is absorbed differently with the various senses, e.g. hearing, seeing or touching. The actual experience of touching and operating equipment is one of *breaking down barriers*. Once performed personally, it becomes real and possible. Until then, it's something a student has not done personally, so in some sense he or she is not truly connected with the material. Once this connection occurs, a change takes place. The student feels like he or she is part of the process.

It is similar to reading about the Champs Elysees in Paris versus standing on it. I can tell you—it's a wide, busy road, and it gives a real feel for Paris that you can't get by reading that it's a wide, busy road. Also, once you've seen it, done it, been there, every time Paris is mentioned, you will respond and think differently. But until *you* actually have *the experience* these words are just hearsay. The same is true of experiences gained in the laboratory.

As far as visualization is concerned, if a picture is worth a thousand words, then a lab experiment or project is worth a whole set of parameters and equations. Suppose students are learning about resonant circuits, and then in the lab they use a function generator and an oscilloscope to observe and change frequencies, amplitudes and phases. Afterwards, while doing more theoretical work, they will think back to the lab experience. The students will recall how these functions behaved then, and will have an easier time

Impartiality in grading papers is important.

understanding how they relate to other applications, such as phasors, impedances, sound and electromagnetic waves, quantum mechanics, and Fourier mathematics.

Computer visualization is getting a lot of attention with engineers devoting much effort to showing how abstract concepts look three-dimensionally. For example, it's one thing to study a simple diagram of an electron wavefunction in a potential well. It's another thing to watch a simulation of its transformation in two dimensions as it reflects off of a complicated set of boundaries; or, better yet, to change the barriers oneself and see what happens.

This is essentially what is done in the undergraduate laboratory setting. If a circuit filters out high frequencies, and students can see that by building and testing it, it is much more than an exercise to validate equations they may already understand. The successful visualization of the effect of behavior of the circuit and its response to various frequencies does more than just reinforce…it creates new pathways in one's mind for visualizing the function. It expands the ability to think about concepts with new pictures that interact with the real world much more than graphs can.

Nuts and bolts

Most of your students will end up getting "real" jobs. You will find that many of them don't share your love of academics, and most will choose careers in some technical area working in an entry level capacity. Even so, many of these students will find themselves in need of the skills gained in your lab classes. These generally consist of (according to G. Carter et al):

• Re-enforcement of lecture material;

• Use of specific, often complex, lab equipment;

• Ability to observe and record data in a meaningful way;

• Ability to communicate through formal report writing, and

• Development of the distinction between theoretical and real-world situations.

The skills gained in the lab are multidimensional, as seen from the list. As the lab TA, you will be responsible for all aspects of the lab. It is important, firstly, to be interested and fair in dealing with the students. Get to know their names and a little about each student: where they are from, their hobbies, etc. Grading assignments is critical to the students' perception of your fairness. Grading fairly is an ethical obligation on your part that you need to take seriously. I suggest when starting a grading session, decide what criteria you want to grade on. This is called "primary trait analysis" write B. E. Walvoord and V. J. Anderson. If you are grading in a team, discuss these issues first, being careful to understand your goals in assigning a grade, e.g. what was to be learned, how important are certain aspects such as accuracy in data taking, etc. Then, look over the entire set of papers and assign a set of grades lightly in pencil or on another sheet of paper. It is difficult to gauge the quality of work in any student paper outside of the context of the entire class. Once you have familiarized yourself with the collection of difficulties, errors, and ways of doing exemplary work, then you can more comfortably assign grades to each paper and feel that you have acted fairly to each student.

One of the most satisfying parts of being a TA will be giving lectures. Your ability to stand confidently in front of a group and deliver material clearly and with authority will serve you well in your upcoming research careers. It is not a coincidence that research and teaching go hand in hand. The ability to learn and then explain clearly is common to both activities. Be sure to write legibly, speak loudly and address the class. Assume a friendly demeanor when inviting questions. Give plenty of time for questions to form in the students' minds and to come out of their mouths.

Also, be on guard for the "watchers" who sit beside the "doers" in lab groups. The watchers may feel insecure, or be too timid or polite to take the initiative. Sometimes they are just disinterested or even lazy. No matter what the reason, you should watch for them and push them to exchange places with the doers. They need to personally interact with the laboratory project in order to derive the full benefit.

To be the best possible TA then, you should be well prepared (go into the lab in advance and do the exercises), ask your professors for help when you need it, get to know the students, be fair, and be enthusiastic. If you do all these things, then you cannot help but succeed.

And lastly…

One last piece of advice that pertains more to your present stage of your career than being a TA: *Don't pass up opportunities*. Learn to recognize situations that could help you. One example is to join one or more professional societies. Student memberships are not expensive, and you cannot fully anticipate what they could do for your career. You can meet working engineers who can influence hiring decisions, you can learn about career paths, and you might learn something that could affect your research. The point is that in advance of knowing the outcome, you cannot afford *not* to place yourself in situations where your career could be enhanced. This will have a positive impact on both you and your students. I wish you the best of luck with both teaching and your graduate education.

Acknowledgement

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Read more about it

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Gary H. Bernstein received his B.S.E.E. from the University of Connecticut, Storrs, in 1979, M.S.E.E. from Purdue University, W. Lafayette, IN in 1981, and Ph.D. from Arizona State University, Tempe, AZ, in 1987. Dr. Bernstein joined the faculty at the University of Notre Dame in 1988, and received an NSF White House Presidential Faculty Fellowship in 1992.

He is now Professor and Associate Chair of the Department of Electrical Engineering. The recipient of a 2001 Notre Dame Kaneb Teaching Award, Dr. Bernstein has authored or co-authored more than 90 publications in the areas of electron beam lithography, quantum electronics, ultrahigh speed integrated circuits, electromigration, and MEMS processing.