Statement of Teaching

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I thoroughly enjoy engaging students inside and outside of the classroom. In both settings, it is exciting to facilitate intellectual growth, including professional development, in both the students and in myself. Below, I describe my teaching of an upper division undergraduate course in general terms, both inside (Section 1) and outside (Section 2) of the classroom. Section 3 discusses the specific content of the course. Section 4 gives course instructor survey results.

1. Making Lecture Rigorous and Relevant

In lecture, I try to motivate learning the material by showing how it fits into the course, future electives, industry practice, and graduate study. We discuss industry trends, current events, and research results, including those from my research group. Integrating industry trends and research results into the course also helps students plan their career path after graduation in terms of companies to join, products to design and topics to research. Showing students how the material is relevant appears to be key in capturing their interests, thereby motivating them to devote significant amount of time outside of the class in studying and internalizing the material.

Here are other ways I’ve tried to make undergraduate course lectures both rigorous and relevant:

- **Lecture Style.** Before lecture begins, I play a video for 3-5 minutes while I am writing announcements on the board. About half of the videos relate to the content of the course and serve as a conversation starter for the lecture content, whereas the other videos are for fun and often relate to the Austin music scene. I take student requests for both kinds of videos. We then discuss current and recent events related to course, esp. to the lecture topic of the day. I then ask “Are there any questions?”, which is a practice that I borrowed from one of colleagues [1]. Next, I then review how today’s lecture topic fits into the course, future electives, graduate study and industrial practice. I lecture by going back-and-forth between projecting PowerPoint slides, deriving mathematical relationships on the marker board, and giving computer-based demonstrations. All slides, handouts, and midterm exams are provided to the students before the semester in a course reader that is a free PDF. Students may print a hardcopy. Students are encouraged to take their notes directly in the course reader, which is useful in solving homework problems and midterm problems (see below).

- **Lecture Duration.** For undergraduate courses, I prefer to hold lecture on Mondays, Wednesdays and Fridays (MWF), even though this is inconvenient for my other professional duties. Lecture time on MWF is 50 minutes instead of 75 minutes on Tuesdays and Thursdays. In teaching the same classes in both formats, I have found undergraduates to absorb material in the 50-minute format better. After each MWF lecture, students still have at least two days of calendar time to reflect on the concepts covered in the previous lecture.
• **Homework and Flipped Fridays.** Homework assignments require the student to perform quantitative analysis and interpret the results. I flip the classroom on five Fridays to work homework problems and on one Monday to work midterm #1 problems. When the students hand me their homework assignment at the beginning of lecture, I immediately hand them the solution set in hardcopy. The solution set would also available online at that time. For the each of the first six homework assignments except for the fourth one, we then work through the solution set interactively by using document projection and the marker board. The problems are very fresh in the students’ minds the day they turn in homework vs. waiting until a later class period to go over the solutions. Those students who didn’t attempt the homework assignment can at least get the key ideas in the assignment, which will be built upon in subsequent lectures. For the midterm #1 exam, which is on a Friday, I return the graded exams during the next lecture period (Monday) and work through the solutions using document projection with marker board annotations. It simply wouldn’t be possible to work the midterm #1 problems immediately after the students would have taken the exam.

• **In-Class Examinations.** The two midterms are open notes, open books and open laptops, but closed Internet or other network access. The idea is to give the students the same environment as they had when working homework problems, except that network access cannot be granted to avoid possible academic dishonesty. Each midterm has four problems. Problem #1 is based on fundamental principles that were emphasized on homework problems. Problems #2 and #3 test critical thinking by asking the students to derive new equations and relationships and offer explanations and interpretations of the derivation. Problem #4 tests critical thinking using qualitative analysis in an argumentative essay.

2. **Making the Best of the Learning Opportunities Outside of Lecture**

Outside of lecture, I’ve adopted many teaching methods in the hope of motivating and facilitating student learning (underlined text contains links to Web pages):

• **Rapid Feedback.** The eight homework assignments are due on various Fridays of the semester. When the student turns in the homework assignment, they immediately receive the solution set, which is also available online. Each homework assignment is graded with feedback and returned to the student by the next lecture (Monday). Midterm #1 is given on a Friday, and it is also graded by the next lecture (Monday) with the solution set.

• **Hands-on Learning.** The course meets three hours/week of lecture and three hours/week of laboratory for hands-on learning and design experience. Homework assignments in lecture ask students to perform analysis and design by writing computer simulations [2]. They are constructed to give immediate sensory feedback in the form of visualizations and/or sound. So, too, are weekly laboratory tasks [2]. From the sensory feedback, students know whether or not their design is working correctly. This immediate sensory feedback really helps the students in refining their designs until they give the desired visible or audible responses. Lab concepts are tightly integrated with lecture topics and homework assignments.
- **Open Courseware to Facilitate Self-Study.** I created open courseware of the lecture component of the spring 2014 offering of the course (44 students) to facilitate self-study [3]. I recorded the lecture discussions on video in an on-campus studio, including discussions of homework and midterm #1 solutions, and posted the videos on YouTube for everyone in the world to access. The videos have collectively received 9,222 views as of November 5, 2014, and the number of views is increasing at a rate of about 1,200 per month. This allows students who miss a live lecture in fall 2014 or subsequent semester to be able to view a recent presentation of the same material. Along with the videos, I put online all of the course materials (PowerPoint slides and handouts, as well as past and current midterm exams).

- **Decoupled Class Office Hours and Drop-In Advising Hours.** By decoupling class office hours and drop-in advising hours, students enrolled in my course are not blocked out from asking course-related questions due to other students seeking non-course advice. My weekly office hours are reserved for students in my course. Having office hours immediately after lecture in the lecture room allows a natural continuation of the discussion during lecture time. In the office hours before lecture, which are right outside of the lecture room for convenience of the students, we work problems together on paper, marker board and/or computer. As needed, I ask questions to facilitate a logical analysis of the problem by the student. Separate from office hours, I hold weekly drop-in advising hours for all students at a local café on the edge of campus. We discuss career plans and what to do to fulfill those career plans, including what courses to consider taking, what internships to apply for, and what to do immediately after graduation (e.g., join industry, attend graduate school, or travel the world).

- **Extensive Course Alumni Network.** Of the 1452 students who have taken this course since 1997, 622 have given their permission to list their names on the course alumni Web page. A few days after I submit grades for the semester, I ask the students from that semester’s course if they would like to be listed or not. Many of the students who give their permission to be listed will also send their job title/employer or department/graduate school after finishing their Bachelor’s degree. I manually keep up-to-date with many of the student’s career changes via LinkedIn. The current students in the class can see where alumni of the course have landed. Moreover, the course alumni serve as a massive referral base to help current students land positions at their companies. According to an analysis of 185,000 job hires in 2012 [4], 42% were filled by current employees, 25% by employees of the company, and 18% from job Web sites. The course alumni who are attending or have attended graduate school can also provide helpful advice about graduate studies.

### 3. Discipline-Specific Content of the Course

The above undergraduate course is *EE 445S Real-Time Digital Signal Processing Laboratory* in the Department of Electrical & Computer Engineering (ECE). It is required for certain BS ECE students, and elective for BS Biomedical Engineering and other BS ECE students. I created the course from scratch upon joining UT Austin in fall 1996, and its first offering was in fall 1997. The course meets for three hours per week of lecture and three hours per week of laboratory.
Digital signals convey information for human consumption, e.g. streaming audio or video over the Internet, or convey information for computer consumption, e.g. sending bits from a handheld platform to support a wireless Internet connection. Digital signal processing algorithms attempt to improve the quality of the information in the digital signal. Many possible algorithms exist for a particular task. In the course, students explore a space of possible algorithmic solutions and evaluate their relative merits in terms of signal quality vs. implementation complexity. This is the kind of tradeoff analysis that design engineers in industry make in evaluating how practical algorithms are for inclusion in a commercial product. In the course, the primary application space is communicating bits over the air and over wires. Secondary application spaces include digital audio, image and video processing, as well as biomedical instrumentation.

- **Bridging Application Theory and Software Implementation.** Students model digital signals and signal processing algorithms as mathematical equations, convert mathematical equations to computer simulations in the Matlab programming language, validate and interpret results, implement algorithms in the C programming language on a standalone electronics board, and validate and interpret results. Students quantify design tradeoffs in signal quality vs. implementation complexity in their Matlab and C programs. This is a prototyping cycle commonly used in industry. The implementations give students new insights into the application theory, and students use the insights to develop more efficient algorithms for implementation. Students improve abilities in theory and implementation.

- **Multiple Views.** The course lies at an intersection of mathematics, computer science and engineering. For each major topic, I provide three analysis views—time domain, frequency domain and generalized frequency domain (Laplace and z domains). For each view, I present mathematical tools, 2-D visualizations, and animations. For example, I show how to create a chorus of the same instrument from one instrument playing by taking the audio signal, delaying it by varying amounts of time and adding up all of the delayed versions. As another example, I show an animation of a wheel spinning faster and faster in one direction. Eventually, the wheel spins too fast for our eyes to follow—the wheel appears to slow down, then rotate the other direction, then speed up, then slow down, then rotate the original direction, etc. The third example is a sampling demonstration (starts at the 47:39 mark).

- **Bringing Research into the Classroom.** I bring graduate-level research project results into lectures, homeworks and exams. In lecture 4 on sampling and aliasing, I play videos of the handshake distortion when recording video on smart phones and show the videos after applying our methods to correct for handshake [2]. In lecture 12 on channel modeling, I give examples of challenges in communicating information through air, wires, and water [2]. Throughout the course, I give updates on improvements in data rates and coverage 2-3 years from now in cellular and Wi-Fi service as well as in smart grid communications.

- **Austin or Bust.** The Real-Time Digital Signal Processing Laboratory course is a natural extension of why I came to Austin. I watched Austin City Limits growing up. Then, in 1983, Stevie Ray Vaughan burst onto the national scene, and reinvigorated Rhythm & Blues. In 1996, I joined the faculty at UT Austin. I was hired in Electrical and Computer Engineering
to help strengthen the subarea of digital communication systems, and that’s why I developed the laboratory course from scratch upon arrival. The lifelong connection with the Austin music scene is why I use audio demonstrations in class and play music videos before class.

4. Course Instructor Survey Results

The table below shows the overall instructor rating (OIR) and overall course rating (OCR) on course instructor surveys for all courses I have taught since fall 2009. Ratings are on a five-point scale. Most favorable response has a value of 5. Least favorable response has a value of 1.

The Real-Time Digital Signal Processing Laboratory course is required for BS Electrical and Computer Engineering (ECE) students in the Communications, Signal Processing, Networks and Systems technical core, and elective for BS Biomedical Engineering students and other BS ECE students. The Linear Systems and Signals course is required for all BS ECE students.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course</th>
<th>Division</th>
<th>Enrollment</th>
<th>OIR</th>
<th>OCR</th>
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<td>EE 445S Real-Time DSP Lab</td>
<td>Upper</td>
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## All lectures were recorded in a classroom studio at UT Austin and posted on YouTube. The spring 2014 course (except for the laboratory component) is available as open courseware.

** Overall instructor rating (OIR) of 4.9 was highest among the 87 ECE lecture courses in fall 2013 at both undergraduate and graduate levels. No other ECE course received a 4.9 OIR.

5. References


