STUDENT GENERATED COURSE DEMOS

Robert W. Heath Jr. and Kathy J. Schmidt

Abstract — Actively engaging engineering students in classroom instruction often results in project-centered activities. Generally these projects are selected because of student interest or topic availability. In an advanced graduate level course, EE 381K-9 Advanced Digital Signal Processing, in the Department of Electrical Engineering at The University of Texas at Austin, students are assembling technology-based projects that will be used by other students in the class and in subsequent years. Thus, these projects serve a dual educational purpose: to teach those students who are creating them and to serve as resources to teach future students. This paper describes some of the challenges of developing student generated educational projects and course demos. Outcomes and observations are presented based on a trial run in the fall 2002 class. Specific topics such as the parameters of the assignment, necessary incentives, and mechanisms for collecting feedback are discussed. Numerous suggestions for incorporating these ideas into other classes are provided.

Index Terms — Active and Cooperative Learning; Faculty Innovation Centers; Signal Processing Classes.

INTRODUCTION

Signal processing, whether introduced in a basic course on signals and systems or an advanced course on digital signal processing, is a standard component of the Electrical and Computer Engineering curriculum. Signal processing initiates students into thinking abstractly about signals (not just waveforms) and the systems (not just circuits) that process them. They apply these skills to solve problems in a variety of related areas including communications, networking, and array processing. Courses that teach signal processing theory are usually offered during the sophomore, junior, or senior year of an undergraduate program and at almost every year of a graduate program.

Teaching signal processing, or any class with a strong component of theory and abstract thinking, requires making tradeoffs. Compromises must often be made between introducing the theory and demonstrating the utility of the theory in practical applications.\(^1\) One way to solve this dilemma is to augment traditional instruction in theory with course demos\(^2\) and design projects coupled with software based homework assignments.\(^3\) Demos serve as a context through which concepts can be discussed and thereby stimulate student engagement.\(^4\) A project-centered approach to learning helps students with prerequisite knowledge as well as helping them apply new knowledge. Instructional projects promote “the important role that experience plays in the learning process.”\(^5\) Projects can enable student learning beyond the short term, encourage the ability to synthesize information, and show them how to put information together in new ways. Couple class projects with today’s technological tools and students have the power to apply theory learned in class to sophisticated and realistic engineering applications. The instructional benefits to using technology increase as the use of technology becomes more sophisticated and students are given opportunities to practice higher order thinking.\(^6\)

In this paper we look at a new way to combine active learning with curriculum development through student generated course demos. The essential idea is to assign educational course projects that are completed successively by different students throughout the term and are tied to the syllabus. Each project consists of an interactive computer-based demo, documentation, and a presentation performed by the student. Instructional course projects have a number of advantages including: empowering students to be responsible for their own learning; giving students an opportunity to contribute to the learning of peers and future students; providing a venue to allow students to practice important non-technical skills that are used for communicating and presenting; creating a permanent instructional resource for future classes and other universities. This paper uses a case study of a single classroom experience to explicate the concept of student generated course demos. The study was conducted in an advanced graduate class on digital signal processing, EE 381K-9 Advanced Digital Signal Processing taught in the Department of Electrical and Computer Engineering at The University of Texas at Austin. We describe the process of developing and utilizing student developed course demos, the issues that arose in this process, and the results with suggestions for improvements. While the case study focuses on a specific digital signal processing course, the methods are applicable to a broad range of classes in various engineering disciplines.

THE SETTING

The College of Engineering at The University of Texas at Austin has a key strategic goal to enhance and improve its instructional quality. Effective teaching is a priority in the College and this emphasis on teaching requires support and

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resources. Under the umbrella of the Academic Affairs Office, resides a faculty resource center called the Faculty Innovation Center (FIC). The mission of the FIC is to support instructional innovation by providing instructional and media development services within the College.

One service that the FIC, along with the Office of Special Projects, provides is faculty development. When new faculty are hired, they participate in a new faculty orientation. Beginning in the fall of 2002, the College now provides an engineering track that coincides with the central campus faculty orientation. During this orientation, engineering faculty attended sessions with new faculty across the University as well as discipline-specific sessions. The faculty who attend this orientation then continue as a cohort group who meet monthly all year in order to learn more about teaching as well as practice being a reflective teacher. “Reflective teachers evaluate their teaching by asking the broader questions, ‘are the results good, for whom and in what ways,’ not merely ‘have my objectives been met?’”

The faculty member who instituted these course demos began his teaching career at UT in the spring of 2002. Since the main orientations are held only in the fall semesters, he was able to participate in the first engineering specific program that was conducted in the fall of 2002. As such the groundwork was laid for him to begin to question, in a trusting environment, what was and was not working in his classes. In this particular case, the faculty member was confronted with two challenges: (1) engage the students using active learning methods (we use the term active learning to describe "instructional activities involving students in doing things and thinking about what they are doing" (Bonwell and Eisen 1991). “8 and (2) illustrate difficult concepts using visualization and computer-based demonstrations. As this was the first time this course was taught by the faculty member, these challenges were competing for time spent preparing basic instructional materials. The faculty member approached the FIC to address these challenges.

THE COURSE

Electrical engineering 381K-9, Advanced Digital Signal Processing (ADSP), is taught in the Department of Electrical and Computer Engineering (ECE) at The University of Texas at Austin. EE 381K is an advanced graduate class that focuses mainly on digital systems processing (DSP) algorithms, however statistical signal processing and estimation theory are included. Course topics include:

- Signal modeling: How can we derive compact lossy representations of signals?
- Optimum filtering: How can we derive 'optimal' filters for smoothing, prediction, and noise canceling?
- Spectrum estimation: What is the power spectrum of a discrete-time random process and how do we estimate it in practice?
- Adaptive filtering: How can we optimally or efficiently update the coefficients of our optimum filter to track changes in the input signal?

The goal for the class is to build up the necessary mathematical foundation to allow each of the above questions to be answered in detail.

By nature of the material, the course has a strong theoretical component. Class time is spent primarily on the theoretical topics, as they are typically the most challenging for the students. There is a practical component to all the topics since each theoretical development results in an algorithm that can be used to solve a real problem. Unfortunately, the theoretical presentation often obscures the intuition on how the algorithms actually work. Due to time constraints it is difficult to have students implement every algorithm. A natural alternative is the use of technology-derived demonstrations that allow students to the develop intuition for each algorithm and yet do not require complete implementation. As ADSP is an advanced graduate class, there are not many software-derived demonstrations available for download. Further, since the instructor needs to spend time developing the class, creation of computer-based experiments was out of the question. Student generated course demos provide curriculum development and serve as a valuable learning tool for the students.

The grading breakdown of the course was as follows: 10% for homework, 18% for each of the three midterms, 26% for the final project, and 10% for the educational project and class participation. A final project was substituted for the final exam. Nominally, the educational project was worth 5% and class participation was worth 5%. They were grouped together, however, to provide students with more incentive to work on the educational project.

During the fall 2002 semester, 10 graduate students and two auditors participated in the course. Of those students, there was one undergraduate student; eight second-year master’s students and the remaining were first-year Ph.D. students. The course met twice a week with 75 minutes devoted to each lecture and there were a total of 26 lectures.

COURSE DEMO SETUP

The ADSP course covers a demanding and evolving set of topics. To provide students an in-depth perspective on a topic related to the course material, an educational class project was assigned. The details of the educational project assignment can be found in the Appendix. However, here is a brief summary. After about three weeks of class, projects were individually assigned to the students. The assignments were scheduled so that one student presented in each class period for the next ten lectures (excluding weeks where there were midterm exams). This should not to be confused with a traditional a term project that is due at the end of the
A tentative topic was assigned to each student that corresponded to the material to be covered that day of class. The topic assignment though was flexible. In particular, the students were given two additional options

1. Present on a topic not covered by previous speakers (and not on the list of topics for subsequent speakers).
2. Present an application of something learned in class to an engineering design problem.

Since Advanced Digital Signal Processing is a theoretical class, it was anticipated that many students would choose option two so that they could get a better grasp of the material.

To fulfill the course objectives, each student prepared a demo implemented in MATLAB or LabView and an accompanying presentation (usually a few PowerPoint slides). Fifteen to twenty minutes were allocated for presentation during each class. A laptop computer (provided by the instructor) was used to facilitate demonstration of the algorithms.

Prior to the presentation, colored index cards were distributed to the students. Following the presentation, the students took a few minutes to answer the following questions:

1. What was the best feature of the demo?
2. What did you learn?
3. What suggestions do you have for improvement?

The students did not provide their own name so as to keep the feedback anonymous.

After the presentation, the note cards were collected and read by the instructor. Any special comments made by the students were noted. After a brief review, the note cards were then given to the student presenter in order to facilitate demo revisions based on the suggestions of other students. The note cards were finally returned and kept by the instructor.

The revised demos were made available to the public on the class homepage as they were created. Each student was asked to provide all the files for her demo, a brief set of instructions, and the presentation materials if possible all in a single archived zip file. The demos are arranged on the web page by topic and the students are given full credit for their work.

Some examples of the demos that were generated are provided here. The demo in Fig. 1 was implemented in MATLAB while the demo in Fig. 2 was implemented in LabView. Fig. 1 illustrates an application of the class material to a problem in half-toning. A student is able to change the parameters of the algorithm and see the resulting visuals.

Fig. 2 illustrates the convergence rate of an adaptive filter with different step sizes. The student is able to turn the virtual knob to change the step size and observe in real-time the effect of a change in rate of convergence. In both cases, there are buttons, knobs, and coefficients that can be changed thus providing learner interactions.

The projects were graded coarsely on a ternary scale. If the demo worked, the student received full credit. If the demo did not work but the presentation was acceptable, then the student received half credit. Otherwise the student received no credit. The grading scale, used to give the students the utmost flexibility in accomplishing their project,
was not intended to impose restrictions on the students. Instead we wanted to observe their creativity firsthand.

To motivate the students to do a good job overall there was an educational project competition. The prize for the best project, a coffee mug with the ECE logo, was not announced until the last day of class. On the last day of class, the students voted for the best educational demo. The votes were tabulated in class and the award was given.

**OUTCOMES AND OBSERVATIONS**

Due to the small class size, there were not enough observations to warrant a serious statistical evaluation. Instead we will summarize the main outcomes and our observations about them.

**Outcome 1:** Of the 10 students in the class, one student illustrated an application of what was learned in class, one student created an educational demo on a topic not assigned, and eight created a demo according to the assigned material for that week.

**Observation 1:** It is of interest next time to be less specific about the project topic. Most students put together a project on their nominally assigned topic though they had the freedom to work on any topic. It would have been especially nice to see more applications of the material learned in class. The class used for this experiment is an advanced class on digital signal processing. The material is mathematical and abstract but has many applications to different problems in electrical engineering.

**Outcome 2:** In response to question two (What did you learn?), students usually were able to summarize what they learned from the demo though it seemed that they often just summarized the topic. Many students, however, did not provide much feedback on their index cards for question three (Suggestions for improvement). Sometimes the feedback was good but lacking, e.g., “The demo could be more interactive – it seemed sort of disjointed” or “add more examples.” Sometimes they made small comments: “Label the graphs on the plots.” Often though students did not give suggestions for improvement and they just left it blank or responded with “not really.”

**Observation 2:** We need to find a way to encourage students to provide serious feedback. Do students need to be provided with more specific criteria by which to assess other projects? Having anonymous feedback seems to prevent accountability and being a good citizen in the class does not seem to have an intrinsic value. Is there a way to ensure good student assessment? Do small index cards encourage students to write too little?

**Outcome 3:** The first educational demo and presentation made in the class were very good. This demo set the stage for the demos throughout the remainder of the semester.

**Observation 3:** The process should be initialized with a good presentation. Perhaps the faculty member should create an appropriate demo and provide an example of what is expected. Of course, once demos from previous classes are available, it will be possible for the faculty member to show the best of the previous demos. Alternatively, since graduate students are often around for years, the previous grad student could deliver the best previous demo, if she is willing.

**Outcome 4:** The students in the class typically did not go home and try out the demos of the other students.

**Observation 4:** It would be useful to figure out how to get the students to try out different demos to enhance their learning. Should homework assignments involve solving something with one of the previous demos? Perhaps when the demos are available for the following year, they will get more use. Also, perhaps demos do not appeal to graduate students as much as undergraduate students.

One solution to this problem is to do the following. One student creates the demo and another student presents the demo. In this way, the demonstrating student will provide feedback and it may be easier to assess the degree of learning based on the experiences of the student performing the demo.

**Outcome 5:** In the room given for this class there was a computer projector but no computer. Consequently, the instructor’s laptop had to be used for the demos. However, the instructor’s laptop contained older versions of some software, MATLAB in particular, and this caused some students’ demos to fail. Further the instructor needed to obtain the demos ahead of time. Many students, however, emailed the instructor the day before or brought a floppy disk when there was no floppy drive.

**Observation 5:** Adequate computer facilities need to be available in the classroom. While larger classrooms in the College of Engineering have a multi-media PC, the smaller classrooms are not always similarly equipped. Lack of classroom technology can cause more work for the instructor and result in wasted class time.

**Outcome 6:** Assessment of the student learning that resulted from the educational project was more difficult than expected.

**Observation 6:** It seems that each individual student benefited by implementing some algorithms in the particular area that was assigned. At the same time, however, they still grumble about the extra work involved. Of course, student satisfaction is not necessarily a measure of learning that was involved. In future revisions of the course, better evaluation methods should be used.

**Outcome 7:** For the class considered, there was both an educational project and a final project. The students, however, indicated that the resulting workload from having two projects was too high.

**Observation 7:** The educational project and final project were rather disjointed since the former was due depending on the assigned date and the latter was due at the end of the term. All the students had the option of doing something related to their final project yet not one student took advantage of this potential time saving. One approach
is to simply have an educational component to the final project. The problem with this approach is that all the educational demos would be completed at the end of the term thus they would not be available to enhance learning throughout the semester.

**Outcome 8:** Due to the small class size, students were not allowed to work in groups on their educational project.

**Observation 8:** It seems desirable to have only one educational demo each class period. If the class is offered only twice a week instead of three times a week, this gives an opportunity for approximately 18 demos disallowing the first two weeks and the weeks for each of the three midterm exams. Clearly for larger classes it may be necessary to aggregate students into groups. This may have particular value in undergraduate classes in fulfilling part of the ABET requirements.

**NEXT STEPS: FORMULA FOR SUCCESS.**

Based on our initial experiment, we propose the following factors be considered when planning for student generated course demos:

- Create a classroom atmosphere where student dialogue and input are encouraged. There are many ways to accomplish this, for example, provide opportunities for students to work in small groups and to see where their individual input is contributory. Or when lectures are given, encourage student interactions.
- Ensure that adequate facilities are available for the demos both at the university and in the classroom. Are the appropriate multi-media hooks there for audio or video if needed? Is the demo software readily available to the students after class? Is the software available in class?
- Care must be taken when selecting topics for demos in order to truly engage the students. “To elicit the interest that leads to involvement, the curriculum must take into account the questions that are most intriguing and significant to students and must help students to understand concepts, principles, or skills and bring them to bear on new problems and situations.”

  Providing a default set of topics according to the syllabus is useful to complement the lecture. Additional topics should be suggested and encouraged (not just allowed) especially those that deal with applications. References for interesting applications should be provided.

- Determine the lectures where it is desired that students present their educational demos. Be sensitive to weeks that contain midterms, holidays, and the last week of class.
- Based on the number of lectures and the enrollment, develop specific criteria for selecting student groups. Employ prescreening or random selection because students do not automatically have the skills needed to work and interact in a team. The quality of interpersonal, communication, and teaming skills – often called soft skills – are greatly enhanced when students are taught these skills and given opportunities to practice them. Share with students techniques and strategies for effective group work and evaluate their group and individual efforts and contributions.

  Initialize the process by creating an example of what the students are expected to perform. Create this yourself, have a TA present it, or use a good demo from a previous class.

  Prior to the first presentation, develop evaluative criteria that help students respond to peer assessments. Choose criteria that provide feedback for the student and feedback for revision of the demo. If possible, gather student input on these measures before they are actually used.

  Allow time for students to be reflective. Immediate reactions to demos and presentations are worthwhile, but they may not produce critical reviews. Provide large index cards to students so that the feedback can be tabulated uniformly. Emphasize the value of these tools. Alternatively, consider using web-based feedback that requires students to provide input.

  Ensure students present their demos to the class and if necessary, defend what they’ve developed. Why did they include or not include particular information or why did they take a particular vantage point? This allows them to develop critical communication skills. Consider having a different student try the demo in front of the class.

  Encourage the students to use the demos developed by their colleagues by using them in homework assignments and having exam questions based on the material.

  Develop criteria for evaluating the impact on the students’ learning. Construct midterm evaluations, final evaluations, and if possible a post class evaluation.

  Publish via the web student demos so that they can be valued instructional tools. Give the students credit for their demos. Such “public” usage of these materials should result in higher quality products as well as products that can be improved on an iterative basis.

Finally, since teaching is an ongoing learning process, expect to make adaptations and improvements to this approach.

**CONCLUSION**

While it is clear that course projects generally benefit students by promoting active learning, student generated course demos offer substantial benefits not only to the students implementing the demos, but also to other students using the demo and the instructor. Though it is the students that create and show their demos, the key to success of the entire project is a function of the teaching scenario created.
the teacher. It is the teacher who translates the curriculum and as noted by Eisner, “In the final analysis, what teachers do in the classroom and what students experience define the educational process.” While teacher behaviors are significant in the teaching and learning cycle, teaching strategies also play a major role. However, a teacher’s instructional philosophy influences the successful implementation of different strategies. It seems that those who chose to implement student generated course demos are those who are comfortable with and promote active learning classroom strategies. Thus the right philosophy and teaching style is a natural accompaniment to the proposed teaching strategies.

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APPENDIX

The following (it was reformatted slightly) was given to the students in addition to the syllabus:

Teaching Assignment Information

Introduction

Part of being a successful researcher is learning to teach difficult concepts. This is what you do in conference papers, journal papers, and presentations. As part of your contribution to the general body of knowledge, in this class you will develop an interactive advanced digital signal processing learning module. You will make a brief demonstration (10-20 minutes) of your learning module in class. Other students will use your module to help with their learning. The learning modules will be posted to the external class web page for access by students around the world.

Specifics

You must develop the learning module yourself, i.e. don't take or build on an existing module from the web. You may use any platform that you desire. I recommend using Matlab and writing a simple front-end GUI. You could also use Java, Mathematica, etc. You may develop a module yourself or may work in groups of two. You might want to develop your learning module based on your project. Modules that illustrate challenging concepts using visualization are great. It is even better if there are parameters that you can change in the model, such as the length of the data record or the order of the data filter. You might also compare the operation of different algorithms on a data record of your choice. Grading will be either 0 (no demo, problems with demo), + (demo works, not interactive), ++ (demo works and is interactive).

To make these modules useful for the class, the learning assignments will be distributed throughout the semester following along the material covered in the book. I will assign learning modules in class on or before September 9th, 2002.

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