2006-973: REVIEW OF AN ENGINEERING TECHNOLOGY GRADUATE COURSE PROJECT TO DEVELOP UNDERGRADUATE COURSE LABORATORY CURRICULUM

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Review of an Engineering Technology Graduate Course Project to Develop Undergraduate Course Laboratory Curriculum

Abstract – This paper details a graduate course project to develop a laboratory series for an undergraduate course in wireless communications. The methodology and outcomes of the project are examined. The project produced a successful and well-received series of laboratories which have been fully implemented into existing undergraduate curriculum. Graduate student participants were able to meet the technical challenges of the project with minimal faculty assistance; however, some experienced difficulty in developing conceptual questions and threads when developing laboratory analysis exercises.

Introduction

This paper addresses a collaborative method in which members of an engineering technology graduate course elected to revive and enhance an undergraduate electronics communications laboratory course as a component of a group project. Although material presented herein contains specific technical detail pertaining to the given project, the overall approach and methods can be adapted to curricula across a range of disciplines. The process and implementation of this idea is not new;[1,2] however, this work includes the additional complexity of utilizing graduate student input and perspectives in the development of curriculum beyond technical aspects of laboratory experiments.

A primary outcome of this project was to provide graduate students with a challenging and useful project and exposure to undergraduate curriculum development. Implementation of this type of collaborative development activity has many positive effects for faculty, graduate students and undergraduate students.

- Faculty realize benefit from a technological update of undergraduate laboratory content in an expedited time frame.
- The process of the group collaboration in the graduate course creates a team environment where the faculty role changes from 'teacher' to 'project leader' with the student having a more collegial role.
- Graduate students gain exposure to the curriculum development process.
- Graduate students exhibit increased commitment and enthusiasm knowing the project will be fully implemented, thoroughly tested by undergraduate students, and will have a significant impact on the laboratory content of a course.
- Undergraduate students benefit from an updated laboratory experience with increased relevance, exposure to graduate students in roles other than teaching assistants, and exposure to the processes used in the development of engineering projects.

Graduate teaching assistant training programs provide graduate students with an introduction to techniques in lecturing, problem solving, interaction with undergraduate students, and grading.[3,4] While the University provides GTA training which allows students to successfully assist in instruction, very few are exposed to the curriculum development process for the materials they teach. This project provided some participants with their first experience in curriculum design.

Specific deliverables required of the graduate project included the design or revision of laboratory instructions, design of circuitry and specifications, determination of relevant test measurements, and development of analysis and discussion questions.

Background

The project was conducted in a graduate engineering technology course in applied electromagnetics. The project's resulting laboratory experiments were implemented and tested in an undergraduate course in the fundamentals of electronic communication systems. Both courses are part of a four course sequence with the graduate course serving as the most advanced and the undergraduate as the introductory course. The graduate course included a requirement for a student-selected project and presentation relating to applications in electromagnetics which were met by the undergraduate curriculum redevelopment project.

The graduate course was made up of six students with varying instructional and industrial experience; one had instructional, industrial and curriculum development experience, one had instructional and industrial experience, three had instructional experience and one was a new graduate student with no instructional experience. Five of the six participants had taken the original undergraduate course over a range of years.

The undergraduate course was an introductory electronics communication course that was in need of a technological update. The course covers basic analog and digital modulation schemes, frequency conversion systems, RF transmission and reception principles, RF amplifiers and filters. The course is a core component of the baccalaureate degree and typically has an annual enrollment of 100 students.

Implementation

The first step of the laboratory overhaul was to review existing labs and identify areas needing change in order to develop an overall project plan. The original undergraduate course had eight laboratory experiments spread over a 15 week semester, including a five week project in which RF isolation techniques were investigated using various printed circuit board design methodologies.

The review resulted in a determination that three labs required minor changes (less than 25%), three labs required major changes (greater that 50%) and two labs, including the RF isolation project, should be eliminated. The graduate students concluded a new project based on a superheterodyne RF receiver would fit well with the objectives of the undergraduate course. This new project required that the graduate students meet the technical demands of design, part selection, prototyping, and measurement while fully addressing the issues of stability and robustness necessary for implementation into an undergraduate course. The new undergraduate laboratory exercises consist of a total of 10 labs including four new labs dedicated to the receiver project.

The graduate student utilized their personal learning experiences in determining to replace the project. Their previous laboratory experiences in the undergraduate course indicated lab experiments were mismatched with lecture material, and the existing project did not successfully tie primary course concepts together. They showed significant insight in structuring lab exercises with lecture content to promote threads in curriculum. Additional insight was provided by structuring the project into achievable sections over four laboratories. This also mirrored how the undergraduate students would work in subsequent project courses. Breaking the overall project into smaller sections, allowed the undergraduate students to understand and build the receiver in a systematic manner with achievable objectives.

The new undergraduate project required concurrent delivery of lecture topics and laboratory exercises resulting in the phased development of a functional superheterodyne FM receiver. Each phase of development included examination of core component blocks at the system and discrete level, allowing for a conceptual understanding of use and implementation in a broad scope of systems beyond the specific receiver project. This idea provided a lecture topic and course schedule that the faculty used to rearrange, develop and refine the lecture material.

The graduate students were assigned responsibility for specific labs. The new receiver project was divided into three major component blocks which were assigned to individual students. Specific blocks used in the new project were comprised of an impedance matching/amplification (RF LNA) block, a local oscillator (LO) block and a mixer/intermediate filter (mixer/IF) block (figure 1).

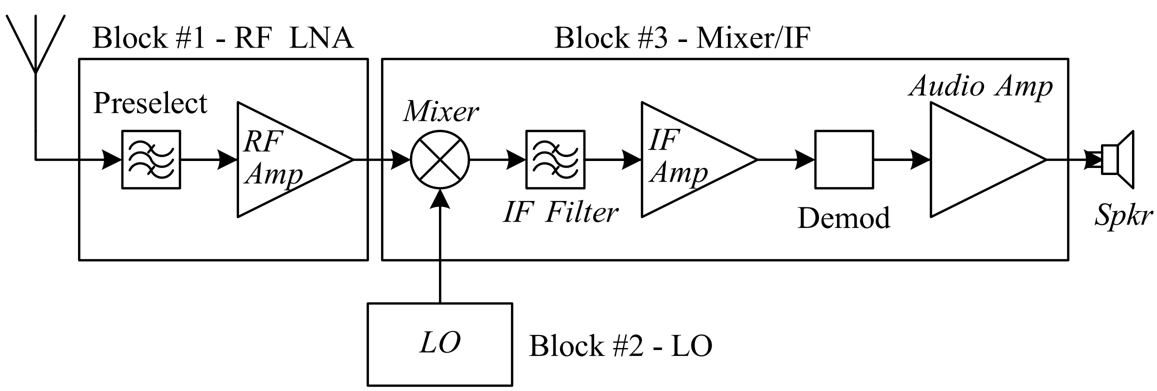

Figure 1 Overall block diagram of superheterodyne FM receiver with the main blocks outlined.

Labs requiring updates were assigned to the remaining students. Each week, the entire class reviewed progress on each lab update or revision. The discussions easily centered on technical topics, including specifications, integration issues and test measurements. Throughout discussions it was evident that students were aware of the primary concepts to be presented in laboratory exercises; however, some students had difficulty in developing laboratory questions to effectively analyze student's comprehension of these concepts. This difficulty typically correlated with the amount of teaching experience held by the graduate student. A key role of the instructor was to provide support to those inexperienced in curriculum design and to focus questions in a manner to maintain concept threads through individual lab exercises.

Each student created a prototype and submitted a detailed list of specifications including actual test measurements of their assigned laboratory. Additionally, students submitted formal laboratory procedures written for a student with an undergraduate level of experience. The instructor assisted in suggesting relevant analysis questions. Prototype circuits were redesigned to reduce component and layout sensitivity and provide additional physical space to ease construction. Most circuits required very limited redesign to achieve final form. Figure 2 shows the variance between prototype and final circuit boards for the mixer/IF board. The majority of changes were to facilitate ease in building or changes in parts to reduce the final cost of the new project.

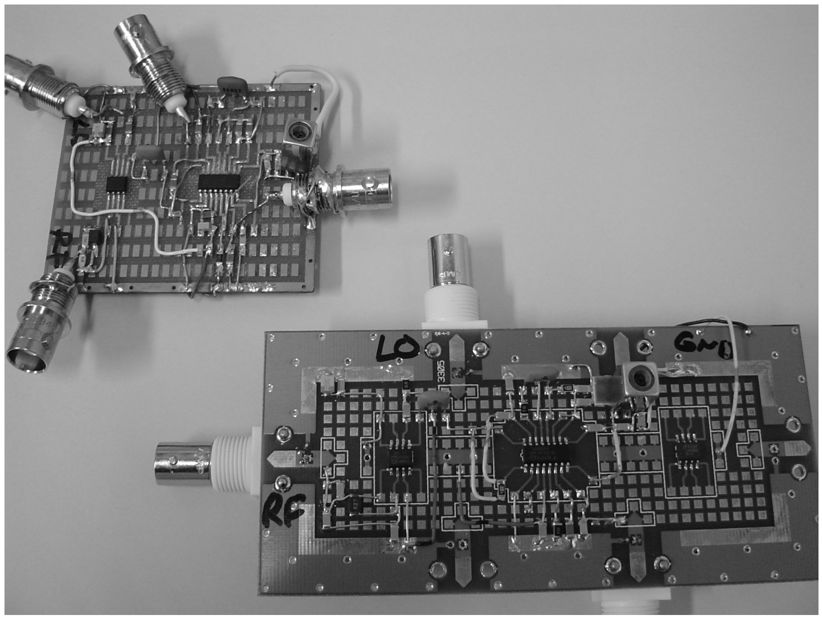

Figure 2 Photograph of rapid prototype of the IF stage (upper left) and final undergraduate version of the IF stage (lower right).

Results

The graduate project submissions exceeded the technical expectations of the faculty. Laboratory procedures and redesigned circuits were implemented in the undergraduate course with great success. Nineteen of twenty undergraduate pairs were successful in constructing and integrating all blocks to achieve a functional receiver during the first offering. The only problems encountered were routine in nature, often related to learning new measurement techniques, failing to completely read instructions or improper circuit fabrication.

Concepts directly relating to current and upcoming laboratories were presented in course lectures from both theoretical and applied perspectives. Issues involving design tradeoff, part selection and circuit layout were presented and related to the laboratory circuits. The graduate students involved in the project would often drop in and assist students with the laboratory and provide insight regarding issues they encountered when developing the prototype circuits while under no requirement for continued participation. Redesigned laboratory experiments were well received by the undergraduate students and a noted increase in performance and overall interest in the course was observed.

Conclusions and Recommendations

Overall, the project was a success; providing graduate students with increased exposure to curriculum development, undergraduate students with relevant and engaging laboratories, and easing the burden of curriculum development on faculty. A graduate project in undergraduate laboratory development provided an efficient use of available resources while providing a mechanism which benefited all involved.

A key component of the success of the graduate project was the engagement of the graduate students resulting from their ability to select the type of project they were able to undertake. It is likely that the level of engagement would be reduced if the nature of the project was assigned by the faculty. For this project, gaining the commitment of the graduate students was essential as the entire process needed to be completed in a six week period.

The primary challenge faced by the faculty during the project was facilitating the creation of appropriate analysis and conceptual questions in student authored lab procedures and maintaining concept threads between multiple laboratory procedures. The students showed an understanding of what was required during project discussion sessions. Linkage between the old updated labs and the new project labs were discussed and outlined. The conceptual questions that were generated tying ideas between lab experiments were poorly structured and the results often related to the student's previous teaching experience. Generally, the graduate student conceptual questions fell back on the more technical aspects of the project. Given the limited timeframe, and the large amount of material that was developed, it was only minor problem, but indicated that creating linkage and conceptual understanding requires instruction and learning to be effective. It is anticipated that this project process will be used in future offerings of this course.

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