Interactive Learning Modules for Innovative Pedagogy in Circuits and Electronics

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Abstract - Students, mainly non-electrical engineering majors, struggle in understanding the Principles of Electrical Engineering course. Some student struggle is probably due to 1) non-electrical engineering majors consider this course to be non-essential, since it is not related to their majors, 2) have difficulty to picture how electric circuits work, and 3) lack of background in electrical engineering. To overcome these struggles, interactive learning modules are created. The revised studio format encourages students to learn by doing, not just listening, and to improve student understanding of difficult concepts. Initial experiences by both faculty and students have been positive.

Index Terms – Active Learning, Collaborative Learning, Electrical Engineering Education, Pedagogy, Interactive Learning Modules.

INTRODUCTION

As is well known, modern four year engineering curricula is crowded, as a result of this crowding not enough time is made available to cover introductory courses in a timely manner. All this is done in order to cover more advanced topics at the junior and senior levels. Since, we are stuck on this trend of packing more material into the curriculum. One way to over-come this crowding is to develop new techniques of teaching to speed up the learning process and to experiment with new methods of teaching. In education there can be no one correct way of teaching but there can always be new ways of teaching.

Here, we propose one new way of teaching introductory circuits and electronics by incorporating active and interactive learning methods. With a diverse student body, formal lectures generally help the gifted students while the less-capable students are left behind. By using active and interactive techniques the student are further engaged in the learning process and enhance the less-capable student in grasping difficult electrical engineering concepts. It also allows the instructor to rapidly evaluate the effectiveness of a particular presentation and to offer best possible aid to students with different learning styles and abilities.

The instructional approach being described in this paper is innovative due to the use of the learning modules. Modularizing course content has distinct advantages as outlined below:

1. Modules enable the portability of course content in terms of learning objectives instead of formalized chapters.
2. They enable the use of course content in different educational endeavors such as continuing education, graduate education, and training sessions.
3. Content modularization encourages students from different educational backgrounds interact equally.

Incorporating active and interactive learning technique is not new [1–7]. On the other hand, its support for teaching at the university level has been a hot topic of research in recent years [8–16].

Active and interactive learning techniques were used in teaching introductory circuits and electronics course on three different State University campuses in the US and one University in China during the academic year 2005 to 2007. The students were from a diverse background and included a wide range of engineering majors.

Today’s engineering students entering college have been brought up with video games and other interactive media find it increasingly difficult to absorb the substance of hour-long formal lectures.

This paper discusses some of the experiences regarding using active and interactive learning techniques and reports the results of the evaluations by students over the aforementioned academic years.

The philosophy behind this teaching format can be summarized as follows: Students learn more efficiently 1) by doing exercises and mini-labs, 2) by active and interactive learning techniques where the students are engaged in discussion and group activities, and 3) by in class assignments instead of passively absorbing lectures [8-16].

PEDAGOGY

I. Educational Background

Many universities throughout the country currently offer introductory courses in circuits for majors and non-majors together in the same classroom. Given the diverse student backgrounds, traditional lectures leave many students struggling to grasp the principles of electric circuits. Some of the students’ struggles are probably due to the fact that non-electrical engineering majors view this course as non-essential. This could be to the perception that it is not related to their major. As a result, they have difficulty in picturing how circuits work.
To help overcome these struggles, active and interactive learning techniques are injected throughout the course. These modules help the student grasp fundamental concepts and build confidence in solving problems as evident from student midterm exams, quizzes and class participation.

Once the students grasp the theory and basic concepts they are introduced to computer simulation tools such as Mathematica, Matlab, or PSpice to further help them solve problems. After manually solving the problems, these computer aided design (CAD) tools serve as a way to check their hand calculations. It also serves as an interactive design space where they can get immediate answers to what if questions.

II. Educational Details

Description of Modules

An introductory electric circuit analysis and electronics course has been taught at the sophomore/junior level at three different State University campuses in the US and one University in China during the academic year 2005 to 2007. During this time, the pedagogy has been evolving to try to accommodate mixed student learning styles. Traditional classroom lectures and homework problems, are supplemented by active and interactive learning techniques to assist in student understanding of the material. The students are given a variety of tasks for the duration of the course: reading, homework, in-class active and interactive group problems, CAD, and outside of class group projects. The topics covered in the circuits course are classical material found in popular textbooks such as [17–19] and for the electronics course [20–22].

Classroom Usage

At the beginning of the course, the class is broken into groups of 3–5 students per group depending on the class size. The instructor by some method chooses the groups, the students are not allowed to choose their teams. Each group will work together on various assignments throughout the course. In-class active and interactive learning methods are typically employed during the course whenever the material covered in lectures allows for it. Occasionally, the groups are asked for a 5–10 minute in-class problem assignment. Fig. 1 illustrates the type of in-class problem assigned, the groups are asked to find the Thevenin equivalent to the left of points A and B.

After the groups have attempted to solve the problem, one student is asked to volunteer (or chosen by the instructor) to present the result of their group’s attempt to the entire class.

Figure 2 illustrates the type of outside of class project assignment, the groups are asked to design the circuit shown below to have a Q-point of ICQ = 1 mA and VCEQ = 10 V. Make the circuit β independent. Show the steps of your design procedure and state your assumptions. Use PSpice to simulate your design. Turn in a copy of the schematic and the portion of the PSpice output file that shows the operating point. What is the percent error in the collector current? Leave the circuit the same but change the β in the simulation to 400 and re-run the simulation. Turn in a print out of the new operating point. By what percentage did the collector current change for this change in β?
instructor randomly chooses one student from different groups to answer questions from the assigned project. Groups are asked to make short 5 minute maximum presentations on the project and each student is also evaluated by their group members.

To help students grasp some fundamental concepts and accelerate the learning process of using CAD tools, a set of tutorials are created. An example of such tutorials is described elsewhere. “The tutorial shows all the required setups, file saving, running the program, and viewing the results through text editor and screen captures. All the main points and steps are explained in detail. Students can go through the tutorial at their own pace and in their own time. There is no rush or time constraints to go through the tutorial.” [23].

The students are also required to complete a series of laboratory experiments. For the circuits course, the laboratory stresses concepts of electrical measurement and presentation of data to compare predicted and observed values. For the electronics course, the laboratory emphasizes applications of analog and digital devices and IC’s.

**STUDIO ASSESSMENT**

This section shows the result of a survey question and also includes some experiences of teaching in China. The students were asked to fill out a survey usually by the end of the course in the academic years from 2005 to 2007. The survey included the following question and had some space left below the question to allow the students to provide some feedback. The students were asked to comment on the different styles of teaching, compared to other courses that do not use active and interactive learning techniques.

Do you feel that active and interactive learning enhanced your understanding compared to a traditional lecture? Why or why not? The Scale is designated as 1 for strongly agree, 2 for agree, 3 for no opinion, 4 for strongly disagree, and 5 for disagree.

Table I details the evaluation responses for the past three academic years. Followed by some comments regarding the students responses to the survey question.

<table>
<thead>
<tr>
<th>TABLE I STUDENT SURVEY RESPONDENTS</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Enrollment</td>
<td>62</td>
<td>67</td>
<td>71</td>
</tr>
<tr>
<td>Number of Respondents</td>
<td>53</td>
<td>56</td>
<td>63</td>
</tr>
<tr>
<td>Response Percentage</td>
<td>85%</td>
<td>84%</td>
<td>89%</td>
</tr>
</tbody>
</table>

Figure 3, shows that the students responded very positively to this question, with 81% of respondents responding “strongly agree” or “agree” in 2005, 89% of respondents responding “strongly agree” or “agree” in 2006, and 90% of respondents responding “strongly agree” or “agree” in 2007. The students enjoyed the different learning opportunities to better match their learning styles. These opportunities included the discussions and the question and answer studio format, traditional homework, in-class and outside of class group problem and project assignments, CAD, and laboratory experiments.

As depicted in the Figure 4, the interactive teaching techniques described in this paper have been shown to be effective in helping students from all engineering disciplines learn circuit theory. It is also observed that successively increasing number of ME students were able to grasp the basics of circuit theory due to the interactive techniques adapted. The Authors hope that this rising trend will continue in the future.

A traditional format analog electronics course was offered during the Summer of 2005, to a total of 79 students, and a pilot studio version of the same course was offered during the Summer of 2006, to a total of 81 students in China from the same faculty. English was the means of Instruction. Students in the pilot class were evaluated with the same exams, as those given to the students enrolled in the traditional format from the previous summer. The studio format in the case of China comparison did not show any significant difference between the exam results, the mean exam scores typically varied by less than 2%. One explanation of this phenomenon is that Chinese students

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have better study habits and generally help each other. It is not unusually strange that students take turn to take notes and then share with the whole class. One difference noticed is that student attendance was dramatically improved using the studio format and more questions were asked during the lectures. Also, students did extremely well in doing their group presentation given that English is not their first language.

CONCLUSION

To summarize, two studio courses in circuits and electronics were successfully implemented. Incorporating active and interactive learning techniques offers a different approach to teaching that helps students with different learning styles and abilities. In this format the less-capable student are not left out as compared to formal lectures where usually the more capable students benefit from the lectures. Also, the students are engaged and the teacher gets immediate feedback on problem areas.

REFERENCES


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