Signals and Systems Lectures Using a Refined "Chalk-and-Talk" Active Learning Approach

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Abstract

Signals and systems is a fundamental course and pre-requisite for several electrical and computer engineering courses. The intrinsic mathematical theory in the course makes it a difficult subject, not only for engineering students to learn, but also for instructors to teach. This mathematical requirement for this subject including some abstracts concepts such as complex domain, frequency domain or even some unrealistic "functions" such as Dirac delta functions makes the subject even more challenging and hard to understand.

In this paper, we described the use of a refined version of "Chalk-and-Talk" to teach a signals and systems class. The methods used here is essentially a traditional PowerPoint presentation coupled with the "Chalk-and-Talk" method to support the theory and achieve a deeper understanding for the students.

Introduction

Signals and systems is an essential prerequisite for electrical and computer engineering classes, such as analog and digital communication systems, control systems, digital signal processing and detection and estimation theory. It is well known that signals and systems is a challenging course, both for students to learn and for lecturers to teach [1]. The course is mathematically intensive [2] and requires a strong knowledge of differential equations, integration, and complex numbers. The course deals with many abstract concepts that are hard to implement or demonstrate in daily experience [3], such as Dirac delta function or Frequency domain. The topics typically covered in this class include Laplace transforms, Z-transforms, Fourier series, Fourier transforms, and convolution. Therefore, it is important to go beyond the traditional PowerPoint-based teaching methodology and consider more interactive methods.

Research has shown that learners tend to retain more information when they are engaged in their learning process. Therefore, a modified "Chalk-and-Talk" active learning approach [4, 5] has been considered as a teaching style for this class. The refined "Chalk-and-Talk" approach used in this class combines the PowerPoint lecture style with the traditional chalk-and-talk teaching style. The idea can be summarized as follows:

- Lecture notes (Talk): A traditional PowerPoint-based lecture was used to introduce new concepts and theoretical topics. Printed lecture handouts, however, includes examples and derivations with white spaces that can be filled-in as in class exercises to reinforce the concepts and theory learned in lecture.
- Exercises (Chalk): For the in-class exercises, a chalkboard was used. In this stage, several active learning techniques can be used, such as share and pair, "One minute Paper", step-by-step solution, etc...

The advantage of this approach is that it can supplement rather than replace lectures. It can be easily implemented in any lecture style. In addition to that, it accommodates a wider range of learning styles: auditory, visual and tactile learners. In addition to that, an application was demonstrated in class to enhance the students understanding using in-class practical experiment.

The rest of this paper is organized as follows: the next section describes the course, its catalog description and its educational objectives. The next section details the teaching methods used in this class by providing some examples from the lectures. Finally, we show the assessment results of the last offerings of the class and conclude the paper.

Course Description

At Valparaiso University, the signals and systems course is a required course for all electrical engineering and computer engineering majors. It is also a pre-requisite for several junior and senior classes such as communication systems, digital signal processing and control system design. The class is three credit-hours taught in a lecture type classroom that is equipped with various technologies such as PC and webcam

The catalog description of the class is as follows:

Signals and Systems 3 Cr.
Continuous and discrete systems and signals are considered in both time and frequency domains. Continuous-time linear systems topics include Fourier series, Fourier transforms, and Laplace transforms. Discrete-time topics include the discrete Fourier transform, the Z-transform, sampling, quantization, and discrete-time processing. Discrete and continuous filtering techniques are introduced.

Upon successful completion of the signals and systems class, students will be able to

- Perform graphical convolution in the time and frequency domain
- Calculate the output of a discrete or continuous system
- Relate a difference or differential equation to its transfer function
- Relate pole locations to time-domain response in continuous and discrete-time systems
- Determine the stability of continuous-time and discrete-time transfer functions
- Compute the frequency response of continuous-time and discrete-time transfer functions
- Explain the sampling theorem, Nyquist frequency, and how to identify alias frequencies.

Refined "Chalk-and-Talk" Method

Traditionally, the teacher spends more time standing at the front of the class, and passively delivering the information with the aid of a chalkboard (chalk-and-talk method) [6]. The *refined* "Chalk-and-Talk" method proposed here is a combination of PowerPoint and chalkboard usage. The concepts that require visualization such as graphical convolution, drawings or discretization can be covered using the traditional PowerPoint slides. With the help of animations and colors in PowerPoint, these concepts can be better delivered to the students (a slide example is shown in Fig. 1).

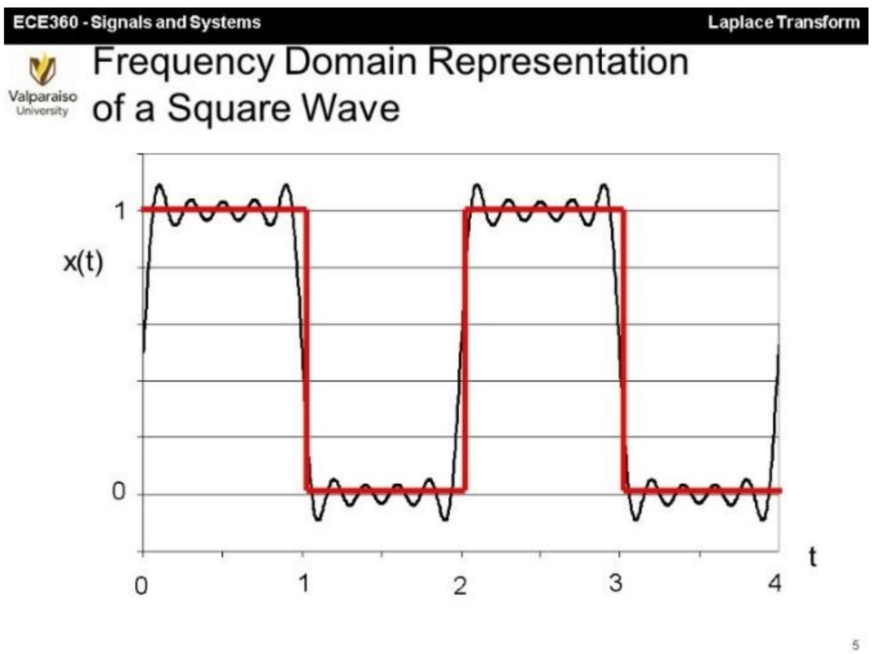


Figure 1: PowerPoint slide showing a drawing for a complicated signal using different colors for different functions

On the other hand, mathematical derivation and line-by-line examples are not communicated well by PowerPoint. Therefore, these components of the class are done on the chalkboard. An example of such material is shown in Fig. 2-(a). In the lecture notes provided to the students, however, all the exercises and the derivation slides are left blank for the students to fill during the lecture. An example of the handout given to the students is show in Fig. 2-(b). Now, each step can be written separately by the lecturer and the students. This allows the lecturer to pause and explain while the students can see the process of the solution step-by-step and have the opportunity to think and ask questions. Additionally, the instructor can pose questions to the students about the intermediate steps to keep them engaged with the lecture.

Moreover, several real word examples and demonstration were used to further develop the students' understanding. For instance, after explaining the system response in time and *s*-

domain, a closed-loop feedback system example was used to demonstrate the concept. The three damping stages (critical damping, over-damping and under-damping) were shown in an example to control a DC motor. The block diagram used is shown in Fig. 3(a). The examples were then explained step-by-step using the "Chalk-and-Talk" method while students take notes on their blank-slides in their handout. The block diagram of the circuit is shown in Fig. 3 (a).

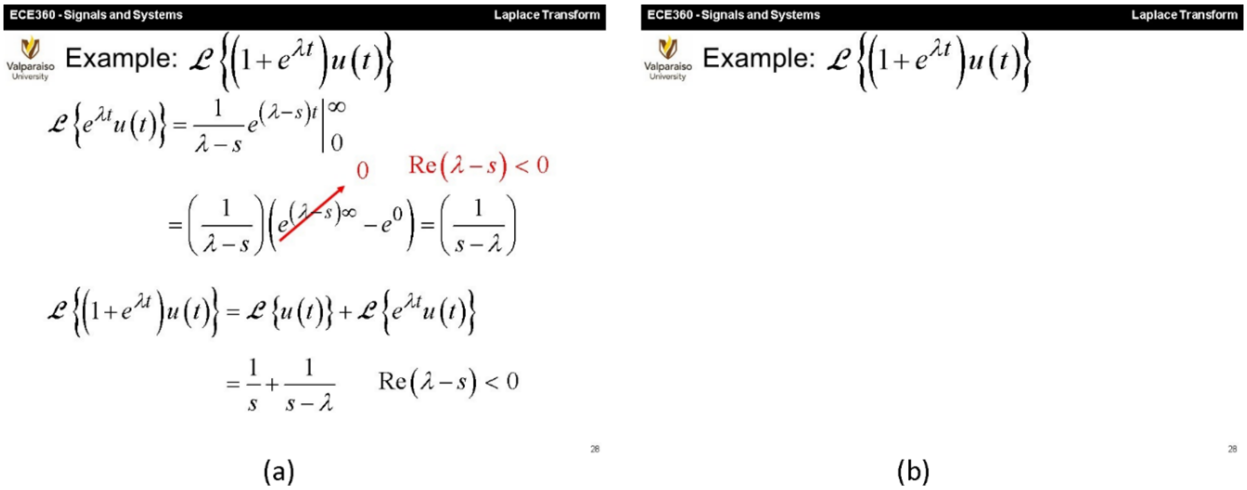


Figure 2: (a) The traditional method to show derivation and examples in PowerPoint. (b) A blank handout that is given to the students to take notes while the example is explained using "Chalk-and-Talk" technique

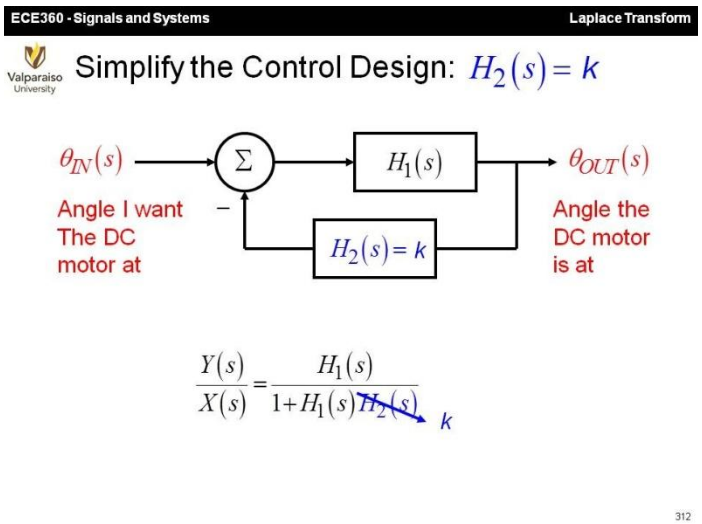
Next, modular servo system equipment, from Feedback Instruments Ltd, was used to demonstrate the example in practice. The setup for the experiment is shown in Fig. 3. The multimedia technologies available in the classroom were again used to project a live video of the demonstration on the screen. The webcam projection was very helpful to keep everyone involved. Finally, time was allotted at the end of demonstration to allow each student the opportunity to approach the setup and investigate different scenarios.

Course Assessment

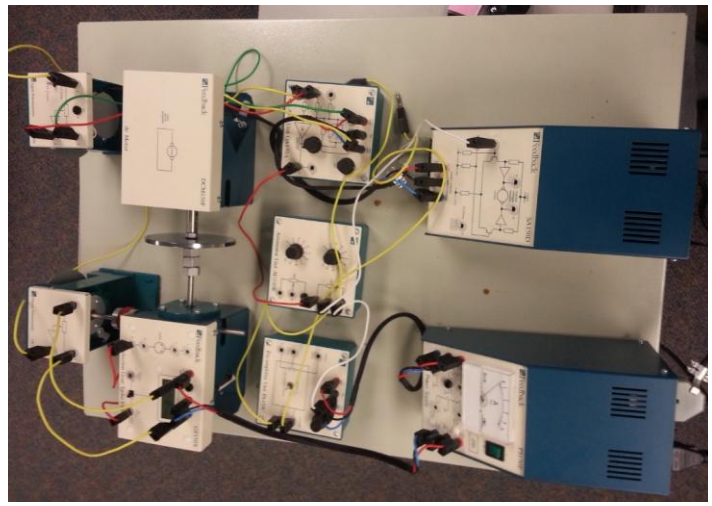
In the first three weeks of this class, the traditional PowerPoint lecture (not the refined method proposed here) was used. At the end of the three weeks, the students were asked to complete a short, preliminary course evaluation survey to provide feedback on their learning experience and make suggestions to improve the lectures. Although the author thought there were enough examples in the PowerPoint slides, the results show that 76% of the students asked for more examples. Some of the comments were like “A few more problems worked on the board would be beneficial.” A different student commented “The PowerPoint is okay but there is no need to come to class except to turn in homework since everything is in the PowerPoint.”

In the remaining of the semester, the refined chalk-and-talk method suggested above was used. At the end of the course, 30 students complete a second class evaluation. Among questions asked in the survey, the following questions were selected:

Q1: Overall, I would rate this course
Q2: Course materials and activities
Q3: Clarity of the instructor's presentation
Q4: Organization and logical arrangement of the course



(a)



(b)

Figure 3:(a) Theoretical example explained in the lecture and (b) demonstrated experimentally in-class using modular servo system from Feedback Instruments Ltd

For each question, students a Likert scale to answer each question:

5. Excellent (or strongly agree)
4. Good (or agree)
3. Average (or neutral)
2. Below Average (or disagree)
1. Poor (or strongly disagree)

The results are shown in Table 1. The majority of the students (27 out of 29) are satisfied with the course materials and activities. Feedback from students suggest that the modified "Chalk-and-Talk" lectures improved their motivation to attend lectures, moderate the pace of lectures and improve their understanding of the materials by following step-by-step problem solving.

Conclusions

This paper showed the effect of a refined "chalk-and-talk" lecturing style on one engineering subject: signals and systems. This class is by nature abstract and highly mathematical. It was found that the refined “Chalk-and-Talk” method provided a very good student learning experience. The combination of PowerPoint and chalkboard methods to teach and learn signals and systems was found to be more suitable tool than PowerPoint or chalkboard alone.

Table 1: Assessment result for signals and system result using the refined "Chalk-and-Talk" method. The chart shows the number of student responses (Excellent through Poor) for the five questions and the average of the student responses for each question.

	5 Excellent	*4 Good*	*3 Average*	*2 Below Avg.*	*1 Poor*	*Average*
Q1	11	14	5	0	0	4.2
Q2	18	9	2	0	0	4.6
Q3	13	9	8	0	0	4.2
Q4	19	9	0	1	1	4.5
Q5	16	6	6	2	0	4.2

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