Studio Laboratory Developed Interactively Between Faculty and Student Facilitate Better Learning Experiences in the Classroom

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Abstract- Educating the leaders of tomorrow's workforce is dependent on the amount of information a student retains. This research shows that studio laboratories that are developed interactively between faculty and students facilitate the quality and success of the classroom experience. This paper discusses the development of a classroom exercise by an undergraduate student which was supervised by a professor and independently evaluated by another undergraduate. Student evaluation shows that the exercise was challenging and applicable to their career goals. We believe the interaction between faculty and students to design and evaluate laboratory assignments is a successful model and should be used in the design of other engineering workshops.

I. INTRODUCTION

Currently, universities are designing and improving the academic environment for college undergraduate students. The student should enjoy learning while envisioning how he or she can apply the skills taught at the university to facilitate their career growth [1]. The lectures, laboratories, and exercises taught in the classroom should give students the foundation to solve the problems that they will face in industry. Universities are offering unconventional methods of teaching classes. For example, pre-college programs are designed for high school students to introduce them to basic theories taught in college. Other methods include incorporating design classes as early as the freshman year to initiate creative thinking and project oriented classes to simulate an industrial environment. Universities are also evaluating if laboratory assignments "foster essential skills", such as taking measurements, learning data collection, instrumentation designs, statistics, etc. [2]

The focus of this paper is an unconventional method that that involves a laboratory exercise designed and written by an upper classman under the guidance of a professor. Students empathize with the confusion many manuals contain. A lab written by students should be easier to understand compared to one written by a professor. The students themselves have recently learned the material and have asked similar questions compared to a professor who may not remember the complexity in learning the present material. Better instructions in laboratory a manual put more emphasis on answering the questions compared to understanding what is being asked.

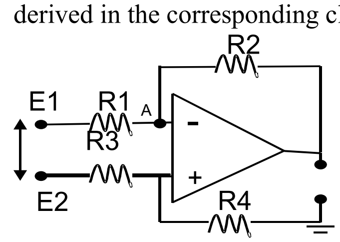
The Whitaker Foundation considers many interesting recommendations to promote learning. One recommendation is using industry equipment and applications in the laboratory experience. This would help the student understand the connection between the classroom lesson and a real world application. We feel that through an interactive laboratory design, faculty gain insights as to when students feel the classroom is a "disconnect" with the "real world" [2]. Students view many assignments as frustrating in content and, more importantly, do not see the correlation or relevance to their career. Another recommendation is to "use current research to bring students to the cutting edge" to promote an interest in learning [1]. If students understand the relevance of the exercise and are interested in the material, it is believed they will retain the information after the course is completed.

II. LABORATORY DESIGN

Instrumentation is a vital part of the curriculum of Biomedical Engineering. It is used in the medical industry, where students upon entering the workforce may design instrumentation devices to record signals from the human body such as the electrocardiogram (ECG). The goal of this laboratory is to have students solve problems that are applicable to those seen in industry. This laboratory manual was designed based on the thought of introducing industry application in the classroom. A key aspect of this paper is to address how instrumentation should be taught in the classroom. First, students should understand the relevance the laboratory has to their career growth. Furthermore, the student should learn to design through creative thinking, measurements, and the interpretation of data using modern technology and equipment. A successful exercise will result in a student retaining the information and lessons taught during the workshop. Students who retain the information have an advantage in the work force. Another important attribute is the oral and written communication skills a student should foster during laboratories. During the design of this laboratory exercise and manual all these attributes were addressed.

Breadboard Design of Differential Amplifier

The first part of the lab is a breadboard design of a differential amplifier. Students work in teams of two to three people. The team is first asked to calculate different gains with the equation and circuit shown in Figure 1. The derivation of the gain equation from the circuit below is derived in the corresponding class lecture.



$$Gain = \frac{Vo}{E2 - E1} = \frac{R2}{R1} = \frac{R4}{R3}$$

Vinput = E2 –E1

R1 =R3 and R2=R4

Figure 1 Electrical Representation and Gain Equation of the Differential Amplifier

The students choose resistor values that will produce a gain between one and five. Then, they are asked to assemble the circuit, which includes learning how to operate several pieces of equipment: the breadboard, DC power supply and a computer which digitizes the output signals and creates the input signals for the amplifier. The software code was written using National Instruments LabView©. Figure 2 shows the block diagram of the equipment the students will be using and how the equipment will be connected.

After the students set up the circuit, they take measurements and analyze the data where they compare the calculated gain to the gain produced by the circuit they designed. Students answer questions to discuss why the theoretical and practical gains differ. They also analyze the saturation effects of the signals.

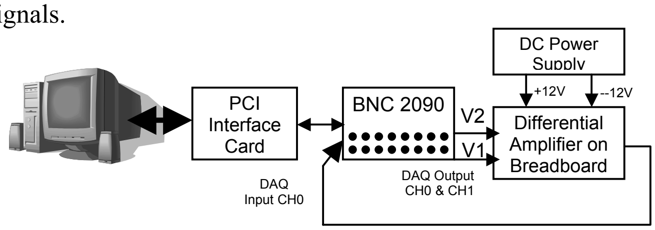


Figure 2: Equipment Block Diagram

Application of Electrocardiogram Simulator and Industry Grade Equipment

The second part of the lab utilizes industry applications by using real world applications and equipment. The signal obtained from their breadboard design is compared to industry equipment, the Grass Amplifier model IP511 A. C. Amplifier. Students also work with an MCI Patient Simulator – Model 430 depicted in Figure 3, which simulates the ECG signal from a person.

Figure 3: The Patient Simulator

In this part of the lab, the simulator is connected to the differential amplifier previously designed by the students using a breadboard. The signal that is coming from the simulator has similar dynamic and temporal content to the ECG from humans, thus this signal is in millivolt range and requires amplification. The student now calculates the gain needed to amplify the small signal to a larger visible one in the volt range, and then designs the differential amplifier circuit, which can produce the required amplification. Students then connect the ECG simulator to the Grass Amplifier to amplify the input signals. Continuing with the Grass Amplifier, the students adjust the low and high cutoff frequency of the Grass Amplifier, and compare the signal from the breadboard design to the Grass amplifier used in industry. Examples of the waveforms the student will see are shown in Figure 4 below.

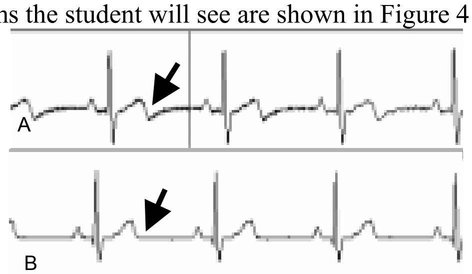


Figure 4: The output signals from the student designed differential amplifier circuit on the breadboard (A) and the Grass Amplifier (B) where differences are highlighted by arrows

Part A of Figure 4 is the signal from the breadboard where all frequencies are present; part B shows the signal from the industry amplifier where a subset of the frequencies are being seen due to the filters of the Grass amplifier. Students are asked to adjust the amplifier to pass frequencies between 1 Hz and 100 Hz discussing the differences between those waveforms, highlighted in Figure 4 with arrows. This part of the lab reinforces the concepts of amplification and frequency taught in the classroom lecture.

Other questions in the lab ask students to discuss the safety difference between the breadboard design and the Grass Amplifier to correlate this lab to the corresponding lecture on medical safety.

III. EVALUATION OF THE LAB MANUAL

A biomedical student who finished two semesters of instrumentation classes participated in the evaluation on this lab manual. She has a similar foundation to the students who would be completing this exercise. The evaluation was done by the student by performing the lab followed by a questionnaire to determine what modifications should be made to the manual and laboratory.

The exercise reinforced electronic circuit design for a biomedical application. Feedback from the student included modification of how questions were worded as well as the omission and addition of questions. On the questionnaire, the student responded that the lab was a positive experience because overall it was well written and allowed her to solve a problem that she felt corresponded with her career goals.

IV. DISCUSSION

A laboratory and manual were designed to reinforce concepts taught during the lecture by building an electronic circuit as well as creative problem solving with a correlation to industry applications. Students begin the lab with instructions on what circuit to assemble as well as what measurements to take. They may use class notes that describe the theory of a differential amplifier. As the lab progresses, students are asked more "independent thinking" questions similar to what a manager or supervisor from industry might ask in a design or an upgrade project based on market specifications. The students must also use their knowledge of frequencies and amplification to manipulate the output signals, which goes beyond "cookbook" laboratory assignments.

The real value of this project was the interaction between students and faculty to develop an exercise that will help facilitate the retention of information to be used after the course is completed. Based on the student feedback, this lab was successful and will be implemented as a studio exercise for the Biomedical Instrumentation Class typically taken by junior and senior undergraduates.

REFERENCES

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