Optimizing Laboratory Curriculum to Enhance Students’ Learning Efficiency in Electrical Engineering Department

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Abstract

Introduction to Electrical Engineering (I2EE) is one of the core courses offered to freshmen in the Electrical and Computer Engineering department at the University of Texas at El Paso (UTEP). The purpose of this course is introducing students to theoretical and practical concepts those form the basis for electrical engineering. Hands-on lab modules have been included as training materials to provide students with helpful guidance to design, analyze and build circuits for a variety of sensor-oriented applications. The I2EE course was adapted from a similar class offered at Olin College, and has been run successfully at UTEP for several years. However, owing to the evolving needs of incoming students, the content and form factor of the laboratory modules was evaluated in order to enhance students’ learning efficiency. A new laboratory worksheet format has been designed, which aims to streamlining the laboratory module process, highlight common mistakes, and to provide clearer guidance to students taking I2EE. Additionally, two new modules have been developed for the class and replaced the old modules to take advantage of the new format. In this paper, the authors will detail the I2EE laboratory class, the original module format, and then detail their newly designed laboratory modules and reporting format to improve student learning success. In order to have a quality assessment, we conducted a survey to evaluate students’ satisfaction in terms of learning outcomes and their contentment from newly developed modules in comparison to three random old modules. The survey result shows that most of the students reflect positive feedback about newly developed lab modules.

Keywords: Laboratory Format, Introduction to Engineering, Electrical Engineering, Circuits, Sensors, Student performance, Evaluation.

Introduction

The University of Texas at El Paso (UTEP) and the Franklin W. Olin College of Engineering (Olin College) have enjoyed a sustained collaboration to share innovative engineering pedagogies [1]. One of these efforts included translating a hands-on laboratory-centered introduction to engineering course from Olin College to UTEP [2, 3]. In order to stimulate students, and encourage self-efficacy and learning empowerment, each student performs laboratory modules using a USB-based instrument (Digilent Inc., Analog Discovery 2) that replaces many of the functions of a traditional electronics test bench [4]. Each laboratory module is designed around an electronic sensor, and students apply their engineering problem solving skills to interface it with the computer, and collect data, all while applying mathematical concepts introduced during lecture. After running this course for several semesters, two major observations were made, where changes to the laboratory modules may increase
student satisfaction as well as their learning efficiency. First, each week students were expected to type up a formal lab report, a time consuming task. Secondly, some of the original laboratories took much longer to complete than others, leading to student complaints.

**Methods**

We have developed two new lab modules using humidity and temperature sensors that replace the longest old modules. These old modules introduced multiple concepts including low pass filters, high pass filters, voltage dividers, and Wheatstone bridge circuits for a single circuit implementation of glucose and strain gauge sensors. We noticed that the inclusion of multiple concepts in one module impeded a deep understanding of the core concepts. Accordingly, the new lab modules have been redesigned in such a way that one key concept is covered in a single module, allowing students to understand that topic. For example, the concept of Wheatstone bridge is presented in the strain gauge sensor module, and the voltage divider and low pass filter topics are separately covered in the new modules of temperature sensor and humidity sensor respectively. Other modules include the same concepts while using different sensors.

Starting in Fall 2019, we updated the format of the lab worksheet by adding pre-lab assignments to the previous modules (those included lab and post-lab tasks), to help students to connect between theory and practice, lab materials, and prepare for lab activities effectively and efficiently. For easy maneuvering, instructional outlines, and response questions, are also added to the worksheets and students are referred to the websites for more details. A completed worksheet is graded each week. We also allowed students to work in groups of two or three for cooperative learning and periodically encouraged students to help each other and prepare themselves to thrive in team activities. Other factors we have considered for successful completion of the lab activities are providing specific clear instructions, discussing activities before students start experiments, giving alerts for common mistakes, and setting up times for completing different tasks.

**Results and Discussion**

Students were assigned to complete one module each week and can attend open lab sections if they need extra time. A standard lab rubric including pre-lab, lab and post-lab components are used to grade students’ lab reports. The performance of students for Fall 2019 and Spring 2019 are compared in order to understand the outcomes of the changes made to improve the lab modules. Student performance was analyzed in terms of module grades and the estimated time required for completion of each module. The average grades of students’ reports and the estimated time are calculated as \( \approx 91\% \) and 2hr respectively for new modules at Fall 2019 whereas average values and time were \( \approx 79\% \) and 5hr respectively for previous modules/format for students during Spring 2019 (Figure 1). It suggests the improved performance of students during the Fall semester in which new lab design was implemented. Figure 2 illustrates the boxplot of students’ report grades for the two redesigned lab modules showing class performance before and after the format change was implemented. In Fall 2019, three quarters of report grades are more than 90 and one quarter between 80 and 90, while grades were ranged between 50 and 100 in Spring 2019. The results indicate better performance of students in Fall 2019 owing to redesigned lab modules.
Figure 1: Performance of students in terms of a) average grades of reports, b) estimated time required for completion of each module

In order to have a quality assessment, we conducted a survey to evaluate students’ satisfaction in terms of learning outcomes and their contentment from newly developed modules in comparison to three random old modules. Most of the students reflected positive feedback about newly developed lab modules. Finally, engaging students in the classroom, allowing them to work in a group, and emphasizing a deep understanding of one/two concepts for each lab (compared to multiple concepts) enhance students’ focus and learning outcomes in a significant way. It is anticipated that the refreshed I2EE laboratory curriculum will further help to attract and excite new electrical engineers. Applying
the new lab design in the current semester (Spring 2020) has resulted in the same observation (efficient delivery of concepts to students and enhancing students' performance).

References


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