Incorporating Electronics in a First Year Engineering Course

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Introduction:

There is no doubt that engineers significantly contribute to the growth of any nation's economy. However, the rate of engineering innovations and initiatives poses a great challenge to the United States (US) due to the high attrition rates observed in engineering programs in the US.

Attrition is recognized as a significant problem in engineering education; engineering programs are reporting graduation rates in the range of 40-60%.[1-7] Students seem to experience a loss of interest and lack of motivation for engineering in part due to the demanding engineering curriculum of the first two years.[2,3] The first two years are recognized as critical to promote student retention in engineering.

To improve retention, the first-year engineering curriculum have experienced significant changes in the last decade. There is a growing trend towards incorporating engineering concepts in first year engineering courses. The purpose is to demonstrate that engineering is fun, rewarding, relevant, and interesting. With these changes, there has been an increase in the implementation of hands on activities that promotes student engagement in a student centered environment.

The objective of this project was to introduce a new module on electronics to students enrolled in a first year engineering program. The module was incorporated in an engineering problem solving course and was designed to include reading material, practice problems, hands-on activities, and a project. This paper describes the content of the module, how the module was implemented, and its impact in students' perception of engineering.

Methodology:

Sample Size**:** 42 students enrolled in an engineering problem solving course participated in this study. All students were enrolled in a first year engineering program at a land-grant institution in the mid-Atlantic region; none of the students have been accepted in a major engineering discipline. Eighty-six percent of the students were male, and all students enrolled were calculus ready. This study was acknowledge by the West Virginia University (WVU) Institutional Review Board (IRB).

Content of Electronics Module: A hands-on module was developed to introduce first year engineering students to electronics. The module's instructional material included the instructor's note, theoretical practice problems, a student handout, and hands-on activities that involved the design of electrical circuits using electrical components.

At the completion of the module, students were expected to be able to

- identify the basic parts of electrical circuits
- design/assemble basic electrical circuits
- distinguish series from parallel circuit connection
- relate voltage and current in a given resistor
- compute the equivalent resistance of series and parallel circuits
- apply knowledge learned on circuits to real world applications

The student handout was divided in the following main sections:

i. Introduction to basic electronic components and function
ii. Types of electronic circuits
iii. Characteristics of electronic circuits
iv. Ohm's law
v. Kirchhoff law
vi. Simple circuit designs/experiments
vii. Basic electronic circuit problem solving and calculations

Pre-test: Students were asked to read the student handout prior to the beginning of the module. A preliminary test was administered to determine student's baseline knowledge on electronics and knowledge gained by reading the handout.

Delivery of the module: The electronics module was delivered in three weeks (5 lectures) and was combined with concepts taught on Excel. Prior to the first lecture, students were asked to read a student handout prepared for the module. Lectures were used for practical demonstration of circuit design and for hands-on activities in which students were asked to design several different circuits, chosen by the instructor. All material used in class was provided by the instructor. The module concluded with a group project in which teams of two students each were asked to design and built an electronic sensor to measure levels of water inside a tank. Students were also asked to perform calculations using excel.

Table 1. Material covered on each lecture

Lectures	Material Covered per Lecture
Lecture #1	-Introduction to Breadboards -How to read resistors' color code -Introduction to circuits -Building basic circuits using breadboards and resistors - Assigned project for the module

Lecture #2	-Introduction to Inductors and LEDs -Building basic circuits using breadboards, inductors, LEDs, and resistors
Lecture #3	-Theory: Ohm's Law Kirchhoff's Law -Practice Problem to design an automatic dark detector
Lecture #4	-Practice problems to apply Ohm's and Kirchhoff's Law -Instructor reviewed student's designs for the project
Lecture #5	-Project (student's demo their final project for the module)

<u>Impact of Module in Student Learning and Perception of Engineering</u>: At the end of the module, students were asked to complete an online survey aimed to assess the impact of the module in students' interest in engineering. The intention of the module was to engage students and to teach them some basic concepts on circuits and electronics. Due to the fact that the module was delivered in a few weeks, we limited the survey to some general questions that allowed us to test knowledge gained from the module as well as any change in interest in engineering.

Results:

<u>Modifications to the course to implement electronics component:</u>

To implement a module on electronics, some minor modifications were implemented into the engineering problem solving course. The module was linked to the excel portion of the course and the project for the module involved excel calculations as well as the design of a sensor to measure levels of water inside a tank. The fact that more time was spent in project #2 caused an overlap between the second and third projects of the course. At the end, students had less time to complete the final design project for the course.

<u>Activities completed in class:</u>

Several hands-on activities were completed during class time to expose students to the design of simple electrical circuits. The activities included building simple circuits using a breadboard, several resistors, and a power supply. Circuits were built with resistors in series and in parallel.

A more complex activity completed during class time involved the assembly of an automatic dark sensing circuit diagram, as shown in Figure 1. For the activity, the class was divided into groups of two students per team. The instructor led the in class activity by explaining the purpose and operation of each of the components in the circuits while students follow each step of the assembly process. The principle of operation of the completed circuit was explained in class and a demonstration followed.

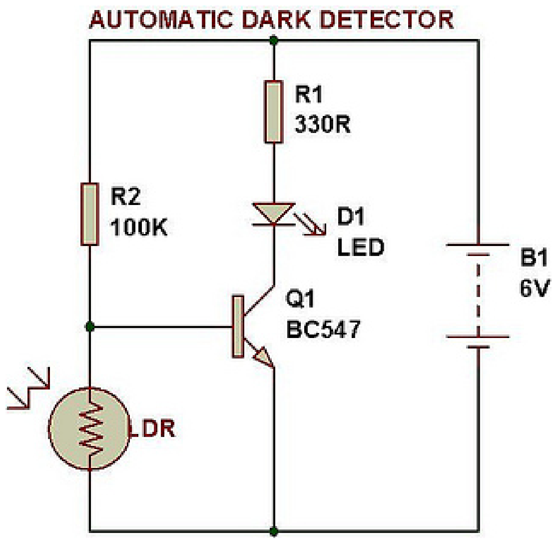

Figure 1: Automatic dark sensor circuit[12]

The final circuit assembled by each team was reviewed by the instructor and feedback was given individually to each team. To design and built an automatic dark sensor circuit, the following components were given to each team

- 330 ohms resistor
- 100 ohms resistor
- 830 pins breadboard
- Jumper wires
- 9V D.C. battery
- BC 547 transistor
- Light dependent resistor
- Light emitting diodes

The estimated cost to build an automatic dark sensor circuit was $7 per team.

Module Project

To merge concepts of electronics with real life applications, students were asked to complete a project that involved the design and assembly of a circuit that will sense different levels of water inside a storage tank, using indicator lights. The design was expected to trigger an alarm once the water level reached full capacity. Students were also asked to prepare an excel spreadsheet that calculates volume of water at different levels inside the storage tank.

Project Circuit Schematic

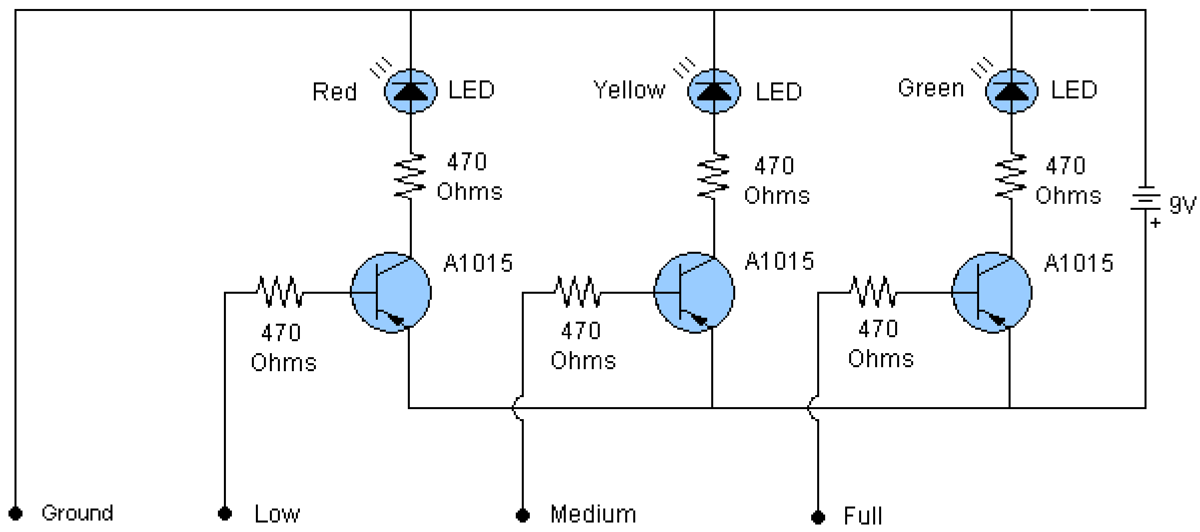

Figure 2: Circuit diagram for water level indicator[13]

The components used to complete the circuit for the water level indicator were:

- 470 ohms resistor x6
- Buzzer alarm
- 830 pins breadboard
- Jumper wires
- 9V D.C. battery
- Storage tank
- A1015 transistor x3
- Probes (cables)
- Light emitting diodes x3 (Red, Yellow and Green)

For the water level indicator, the estimated cost was $12.00 per team.

<u>Analysis of Survey:</u>

Forty-two students enrolled in a problem solving class completed the electronics module as part of the course. Eighty six percent of the students enrolled were male (14% were female) and 53% of them self-identified as first year engineering students. Due to the limited number of students in the study, we decided not to analyze the data by year of study (freshman versus non-freshman).

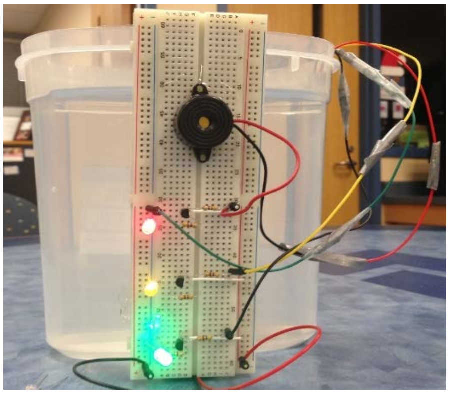

Figure 3: Sensor developed to measure levels of water inside a tank. At level 3, which indicates the tank is full, the attached buzzer alarm goes off simultaneously as the red indicator light comes on

All students were able to complete the circuit designs during class time and completed the final project for the module (see Figure 3). Each team's project was tested during class time using water and students were allowed to modify their final design during based on feedback received given by the instructor.

Based on the survey analysis (as shown in Figure 4), 52% of the students indicated that the electronics module increased their interest in pursuing a degree in engineering, while 40% indicated that the module did not produce a change in their interest in engineering.

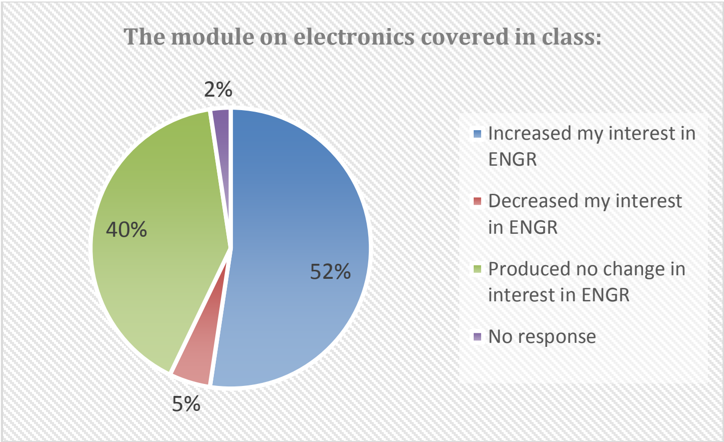

Figure 4: Some student reported an increase in interest in engineering due to the module

According to the survey, 74% of the students recommended that the module should be part of the engineering problem solving class next semester. 79% of the responders also found the module interesting. Five percent of the responders indicated an intent to transfer out engineering program while 95% indicated an interest to continue pursuing a degree in engineering. According to the survey, the module did not promote the pursue of a degree in electrical engineering.

Discussion:

Instructors can potentially influence students' retention rate in engineering by promoting in class activities that engage and attract students to engineering. For first year programs, it can be more challenging to prepare and deliver appropriate engineering projects and activities since students' knowledge of engineering is limited. This paper presents a simple and cost effective module that can be implemented in first year courses to engage students in hands-on activities related to circuits and electronics.

Although several full semester courses have been developed to introduce first year students to circuits and electronics, the simplicity and little time associated to this module make it more suitable for those institutions in which students are required to complete several courses (Mathematics, Chemistry, Calculus I, English, among others) before being accepted into an engineering major.[8,9,14]

One key feature of this module is its cost effectiveness. By designing simple circuits and by encouraging students to work in pairs the instructor was able to reduce the initial cost of the module to $10 per student. Once the module was completed, all materials were collected and kept by the instructor and will be re-used in future courses; this further decreases the long term cost of implementing the module.

The module was well accepted by students. Attendance was mostly 100% throughout the period the module was taught. For every lecture, the class was usually interactive and the questions asked by students were well thought and mainly complemented the instruction given in class.

More advanced activities, such as the design of a clapper sound activated switch, could be implemented in the module. The research group also plan to develop additional modules based on other engineering discipline (such as chemical, mechanical, or civil engineering).

Due to a small sample size and a low percent of underrepresented groups in our course, the authors were unable to analyze the data by gender, ethnicity, or entry level (first semester versus second semester or above). However, we plan to implement the module in Fall 2015 in a larger number of students, which will allow for a more in depth analysis of the data and of the impact of the module in students' confidence, and interest in engineering.

Conclusion:

Losing nearly half of talented first year engineering students is not acceptable and more needs to be done at the educational level to improve retention rates in engineering. This project shows that it is possible to design carefully structured and effective hands-on experiences using a limited budget. Even students that were not planning to pursue a degree in electrical engineering benefited from learning about circuits and reported an increase in interest in engineering due to the exposure to circuits and electronics. More time and effort should be dedicated to the development of effective educational material for engineering courses. Future work will involve the development of modules for other branches of engineering to promote an early exposure to engineering concepts and potentially increase retention in engineering.

Acknowledgements:

This material is based in part upon work supported by the National Sciences Foundation under a RIGEE Grant. Other sources of funding include a grant from EngageEngineering.org and support from the first year engineering program at WVU.

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