Work-in-Progress: A semester-long circuit project for general engineering students

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Abstract

The fundamentals of electrical engineering are typically covered in a semester-long course designed for non-electrical & computer engineering(ECE) students. However, many non-ECE students often lack motivation to take this course. While hands-on projects are commonly used to enhance student motivation and engagement, they are usually conducted at the end of the semester, which may not effectively retain students who lose interest early on. To address this issue and maintain constant motivation, we propose a semester-long circuit project. Intrinsic Motivation Inventory (IMI) and course GPA will be used as evaluation metrics of effectiveness of the proposed project. By implementing this approach, we aim to foster sustained student interest and active participation through the entire course.

Keywords

Circuit project, student motivation

1. Introduction

The introductory electrical engineering courses aims to familiarize non-ECE students with the various specialties within electrical engineering and highlight its close connections to other engineering disciplines. The course covers basic circuit analysis including DC and AC network analysis, as well as providing a brief introduction to analog and digital electronics [1]. Motivating non-ECE students to engage actively in the course presents a challenge, as many may perceive it as merely fulfilling a degree requirement or preparing for the FE exam [2]. To address this issue, the addition of course projects has been proved as an effective strategy in basic electric circuit analysis courses. By building the course around a set of interesting projects and drawing links to real-world applications whenever possible, previous studies [3] have successfully demonstrated the value and relevance of electrical engineering to non-ECE students. For instance, projects like a solar-powered cellphone charger, an electromechanical box with a self-switching mechanism, an LED cube, and an electrocardiograph have received overwhelmingly positive feedback from students, with the only concern being the desire for a lighter workload [3]. The team at University of Oklahoma developed a unique curriculum for teaching circuits and other ECE concepts to non-ECE majors. In their approach, LEGO Mindstorm robotics platform was used for the final project, resulting in favorable evaluation and survey data, indicating the success of this approach [4]. However, the additional hardware cost and additional workload to learn Labview programming should not be neglected. As we proceed, we propose a semester-long circuit project to address the issue of waning student interest and maintain sustained motivation throughout the course. This project will be evaluated using the Intrinsic Motivation Inventory (IMI) and course GPA as metrics to assess its effectiveness in keeping students

engaged and enthusiastic about electrical engineering concepts. The subsequent sections will delve into the details of the proposed semester-long circuit project and its potential impact on student motivation and learning outcomes.

2. Proposed Project

The primary objective of the proposed project is to foster student motivation by hands-on learning experiences while minimizing additional hardware costs and excessive workload. The project should be semester-long to constantly motivate students and also help students understand the engineering design process. Considering these factors, we proposed the "LED dimmer project". The project requires students to design a circuit to control the brightness of an LED powered by battery. Leveraging components already used in the lab course, the project eliminates the need for extra hardware and ensures that it remains within the scope of the course curriculum. This approach enables students to apply their knowledge practically without requiring additional specialized skills. A sample schedule is provided in Table I while Figure1 illustrates the flowchart of project activities. The project commences with an icebreaker session during the first week, facilitating group formation. Then, students will work collaboratively on the project and at the end of fourth week, they will submit a report and prototype for milestone 1. Instructors will assess the reports and provide constructive feedback and suggestions for improvement. In response to the feedback received, students will refine their circuit designs and submit a new iteration at the end of the eighth week. By encouraging this iterative approach, students gain valuable experience in the engineering design process, further enhancing their understanding and problem-solving abilities. Subsequently, at the end of semester, students will present their final reports and prototypes.

Table 1 Schedule of course topics

week	topic	project
1-4	DC circuit, diodes	milestone1
5-8	Transistors	milestone2
9-11	digital circuit	milestone3
12-14	AC circuit	Circuit testing and presentation

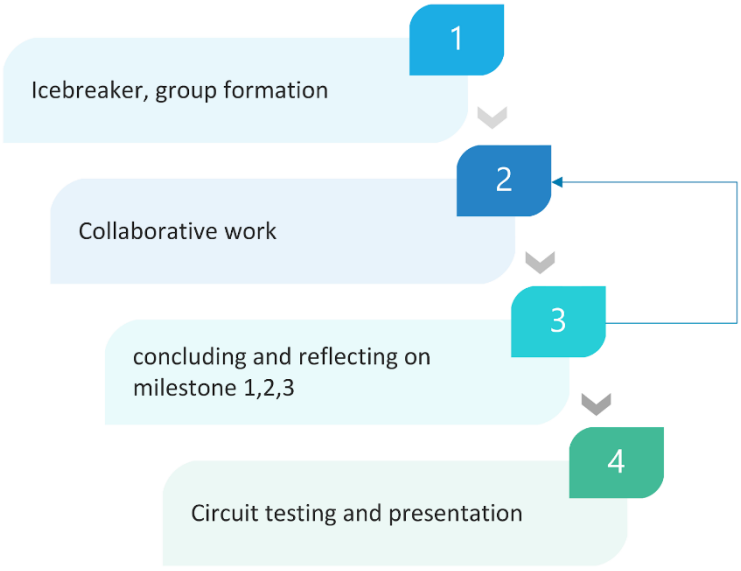

Figure 1. Flowchart of project activities

In each milestone of the proposed project, students will have the opportunity to experience and engage in the engineering design process, as illustrated in Figure 2 [5]. This iterative approach allows students to refine and modify their designs as they progress through the course, gaining deeper insights into the practical application of engineering principles. Unlike the conventional end-of-semester project, the proposed semester-long project gives students more exposure to the iterative engineering design process. This extended timeline allows for a more comprehensive exploration of the design cycle, encouraging students to iterate and improve their solutions as they encounter new concepts and topics throughout the course.

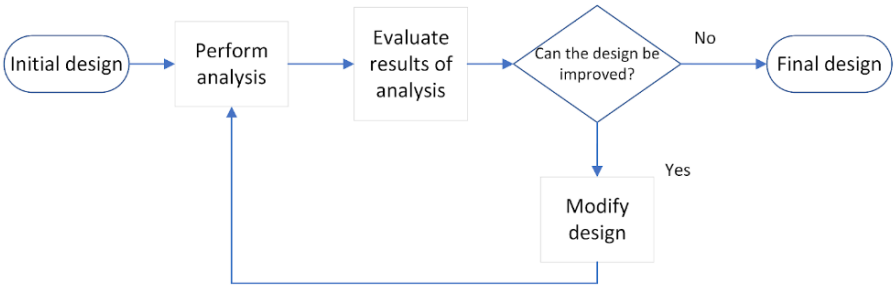

Figure 2 Engineering design process [5].

Throughout the project, students are encouraged to exercise creativity and critical thinking, allowing them to devise unique circuit designs. However, to provide guidance and reference, example circuits for each milestone are also provided. These examples serve as a helpful resource to support students in understanding the expectations and requirements of each stage of the project.

2 .1 Milestone 1

Milestone 1 is at the end of the DC circuit. In milestone 1, students only have already grasped the basic idea and calculation of circuits. The design most students came up with is using variable resistance as shown in Figure 3. Low efficiency is the main limitation of this circuit, and this circuit is seldom commercially used. However, this milestone provides opportunities for students to experience circuit design and how to use what they learned in this course to solve problems as well as how to use breadboard and basic electrical instruments.

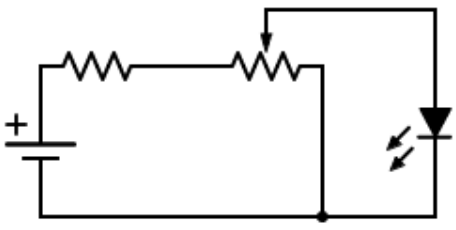

Figure 3 Example circuit for milestone 1.

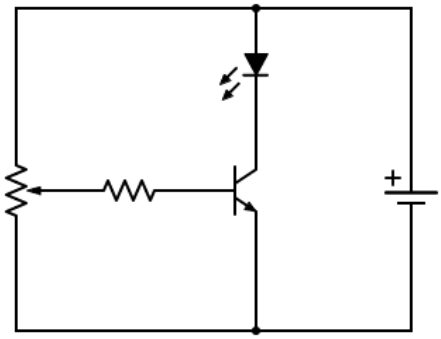

Figure 4. Example circuit for milestone2

2.2 Milestone 2

An example circuit for milestone 2 is shown in Figure 4. After introducing transistor fundamentals, students will be able to incorporate transistors in their design. This improves the efficiency of the circuit compared with the example in milestone 1. This milestone also helps students learn how to read manufacturer manuals and select appropriate devices for the circuit.

2.3 Milestone 3

Milestone 3 is scheduled after the introduction of the digital logic circuit. Once they learn the 555 timer and Pulse-Width-Modulation (PWM), they will be able to design a higher efficient but more sophisticated circuit. This circuit is closer to the commercially available LED dimmer circuit. An exemplary circuit for this milestone is shown in Figure 5.

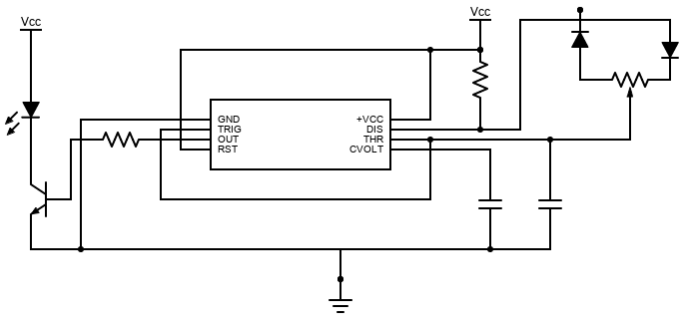

Figure 5. Example circuit for milestone 3.

Finally, circuit testing and presentation will be conducted. Each group will introduce their iterative engineering design process and the improvements they made on each milestone. A final report which includes the circuit design and calculations as well as the presentation determines the score of the project.

3. Discussion & Conclusion

The proposed semester-long circuit project is designed with the primary objective of increasing student motivation, a crucial factor that contributes to student success. The project aims to foster sustained interest and engagement among non-ECE students in the electrical engineering course. To assess the effectiveness of the proposed project, Intrinsic Motivation Inventory (IMI) and course GPA will be used as measurement metrics. The IMI is defined as a validated multidimensional measurement device that has been used to measure the level of intrinsic motivation and self-regulation [7]. The experimental design will involve two groups: the experimental group, which will undergo the proposed semester-long project, and the control group, which will undertake the conventional end-of-semester project. By comparing the outcomes and experiences of both groups, researchers can effectively determine the impact of the semester-long project on student motivation and academic performance. The experiment is planned to be carried out in 2024 and more detailed results and analysis will be presented in the full paper.

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