Electrical Engineering Laboratory Activities for First-Year Students: How to form TIES (Teach, Inspire, Engage, and Stimulate) to STEM

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1. Introduction

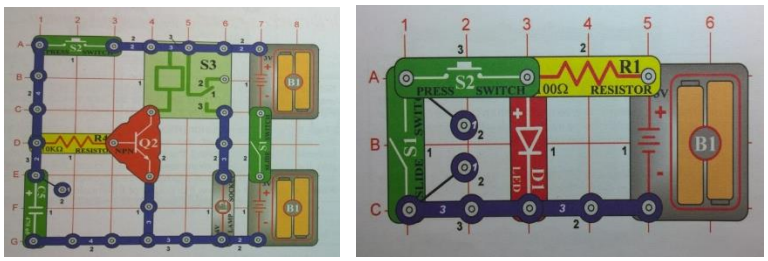
The critical entry-level engineering course, titled *First-Year Seminar in Engineering*, is designed to orient the incoming student to the university and to introduce engineering as a professional field[1]. To form TIES (Teach, Inspire, Engage, and Stimulate) to STEM, the course must comprise hands-on problem-based[2] and project-based[3] engineering laboratory activities. This paper identifies structured laboratory activities in the field of electrical and computer engineering (ECE) with aspects which demonstrate TIES to STEM. The students are expected to engage in laboratory activities lasting approximately fifty-five minutes. During this short time interval, the activities are focused more on experimental observation and data collection than on the critical evaluation of the design process and rigorous mathematical analysis.

2. ECE laboratory activities with TIES to STEM

The TIES to STEM are identified in the ECE laboratory session titled "*ASSEMBLE AND TEST THE TIMER AND LOGIC CIRCUITS*." The specific objectives of the laboratory session are (a) assemble and test a timer circuit using a transistor and a relay to control a light emitting diode (LED) (b) assemble and test logic gates using switches and LEDs.

Teach and Inspire

The students are provided with the laboratory write-up at least one week in advance of the laboratory session. The write-up describes the procedure to assemble and test the timer circuit and each of the logic circuits. At the start of the session, the write-up, the equipment to be used, and the laboratory activities to be performed are briefly reviewed. The timer circuit and the logic circuits are assembled with electronic kits which contain electrical components placed on circuit assembly boards and connected using snap connectors. Figure 1(a) displays a timer circuit. Figure 1(b) illustrates the NAND logic gates implemented using circuit and electronic components.



(a) (b)

Figure 1: (a) Timer circuit (b) Logic circuit

Engage & Stimulate

First, the students engage in the steps to assemble the circuit shown in Figure 1(a). To stimulate student recognition of engineering design specifications and parameter selections, the laboratory exercises related to control of the timer circuit and Boolean operations with logic circuits. Students collect evidence of timer control by choosing the resistors and capacitors from the kit. The evidence is documented as displayed in Table 2. The students assemble the circuits to implement the NOT, AND, NAND, OR, and NOR logic gates. The operation of each gate is documented as shown in Table 3.

Table 2: Timer control data

Resistor, Ohms (Ω)	Capacitor, Farads (F)	Duration, seconds (s)

Table 3: Truth table for logic circuit

Position of the switch S1 (ON/OFF)	Position of the switch S2 (ON/OFF)	LED LIGHT (ON/OFF)

3. Assessment of student performance

For the present study, the fifty-five students in the course were grouped into four sessions. In each session, the students worked in teams of two (arbitrarily assigned by the instructor). The rubric to assess the report is shown in Table 4. Table 5 displays the average score and deviation for the students in each session. The overall average score attained was 78.5%. The 91% average performance of the students in session #2 represented a group of first-year students who had chosen ECE as their intended undergraduate degree. The students in this session were more familiar with the basic ECE concepts. The students in the other sessions, who had chosen engineering majors such as mechanical and environmental, or were undecided, attained the average score of at least 72%.

Table 4: Rubric for assessment of the report

Level of Achievement		
5	**3**	**1**
Organized in sections with accurate grammar and punctuation in the discussion; use of figures and/or tables to analyze the data; presents clear conclusions based on the validation	Some sections lack organization; contains inaccuracies in the use of grammar and punctuation; some use of figures and/or tables to analyze the data; incomplete conclusions	Lacks any organization of the content; poor use of grammar and punctuation; no figures and/or tables for data analysis; no clear conclusions

Table 5: Student performance

Session #	Student count	Average score (on 10)	Deviation
1	14	7.4	1.8
2	14	9.1	0.8
3	18	7.2	2.0
4	19	7.9	1.7

4. Conclusions

Structured ECE laboratory activities in the *First-Year Seminar in Engineering* enable the students to (a) understand and perform engineering laboratory exercises (b) cultivate skills related to experimental observation and evidence collection (c) gain useful STEM experiences for future courses and engineering professions. The number of students switching to ECE from other choices of engineering disciplines prior to the ECE laboratory experiences detailed in this paper serves as a metric of the success of the 'inspire' component.

Bibliography

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