Improving Non-Electrical Engineering Student Engagement and Learning in Introductory Electronics Course through New Technologies

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Abstract

Introductory Electronics course is a requirement for most of the non-electrical engineering students. The course provides a valuable opportunity for students to broaden their knowledge and multidisciplinary skills to be a contributing member of a diverse team meeting complex challenges of emerging problems. Providing valuable experience to students in this course is crucial to help them understand basic concepts in electronics as well as encouraging their interest in electronics. This can be achieved in part by leveraging appropriate technology in the curriculum. The purpose of this paper is to introduce new technologies which enable educators to improve their introductory electronics course curriculum for non-electrical engineering students.

I. Introduction

After 2008 economic crisis, University of Wisconsin-Stout had gone through significant budget cuts like many universities around the country. Universities had been attempting to mitigate this budgets cuts situation by increasing course load, decrease associated costs with maintenance & upgrade of lab equipment, having fewer software licenses, and less lab technician. In the undergraduate education, heavy workload is expected from university professors besides regular teaching duties. They include the requirement of a certain level of research, serving departmental and university-wide committees, and assisting accreditation-related work[1]. All these negative factors degrade the quality of teaching which results in lower student retention rate.[2] Teaching Introduction to Electronics course for non-electrical engineering students for the first time had proven to be a challenging experience for faculty members.[4]

As an example, one of the authors had taught four credit Electronics Circuits, Devices, and Applications course for two semesters for nonelectrical engineering students at the University of Wisconsin-Stout. Course meet three two-hour, two lectures, and one lab. The content of the course is very comprehensive. Topics covered are concepts and analysis techniques in DC and AC circuit analysis, basic electronics theory, devices, logic, including capacitance, inductance, impedance, circuit equations, network theorems, signals, op-amps, transistors, circuit analysis, number systems, combinational logic, minimization, programmable logic devices, state machine algorithms, transition diagrams, asynchronous, and synchronous sequential logic. The course covers almost all content of 3-4 electrical engineering courses we are teaching for electrical engineering students such as Digital Circuits, Analog Circuits, Electronics, and Introduction to Circuits. e

It is extremely challenging for any course instructor to cover such a diverse topic, engage with students, and provide hands-on laboratory experience at the same time. Like many universities, students evaluate the instructor at the end of the semester. Some of the student comments from my first-time teaching were, "*the course being fast pace,*" "*difficult to understand*" and "*too* *much math and very few lab*s." They also mentioned that they were constantly being rushed to finish the lab experiment on time. Overall, student feedback clearly showed that students did not have a positive experience from the only electrical engineering course that they are required to take during their undergraduate education.

As a teaching experiment, the course instructor decided to change the teaching method significantly and use some of the new technology to improve student engagement, make the course more enjoyable and improve student feedback to ensure students complete the course with a strong background in electrical engineering and positive experience. List of new technologies integrated into the course is shown below.

- Online Circuit Simulator Software
- Wolfram Mathematica Demos
- Interactive question applet
- High quality 2D/3D animation videos
- Analog Discovery Kit
- Piazza

II. New technology introduced in the Course

Online Circuit Simulator Software

Non-Electrical Engineering students typically come to class with very limited knowledge in electricity. Since the course has a broad range of topic to cover, the instructor struggles to provide laboratory experience. Students will come with no or minimal experience with lab equipment such as Oscilloscope, function generator, digital multimeter, and DC power supply. It generally takes 2 to 3 weeks to introduce the test equipment to the students. Students will then have only 5 to 6 laboratory exercises to have hands-on experience related to theories covered in the class. Considering all the content needs to be covered in the lecture. Circuit simulation software such as National Instrument Multisim is a great circuit design tool for instructors to help improving students' learning by circuit simulation assignments. At the University of Wisconsin-Stout, we have circuit simulation software installed in lab computers, but not installed on student`s personal computers. Many of these software tools are expensive, and trial versions have limited functionality which prevents students from learning some aspects of the circuit design concepts

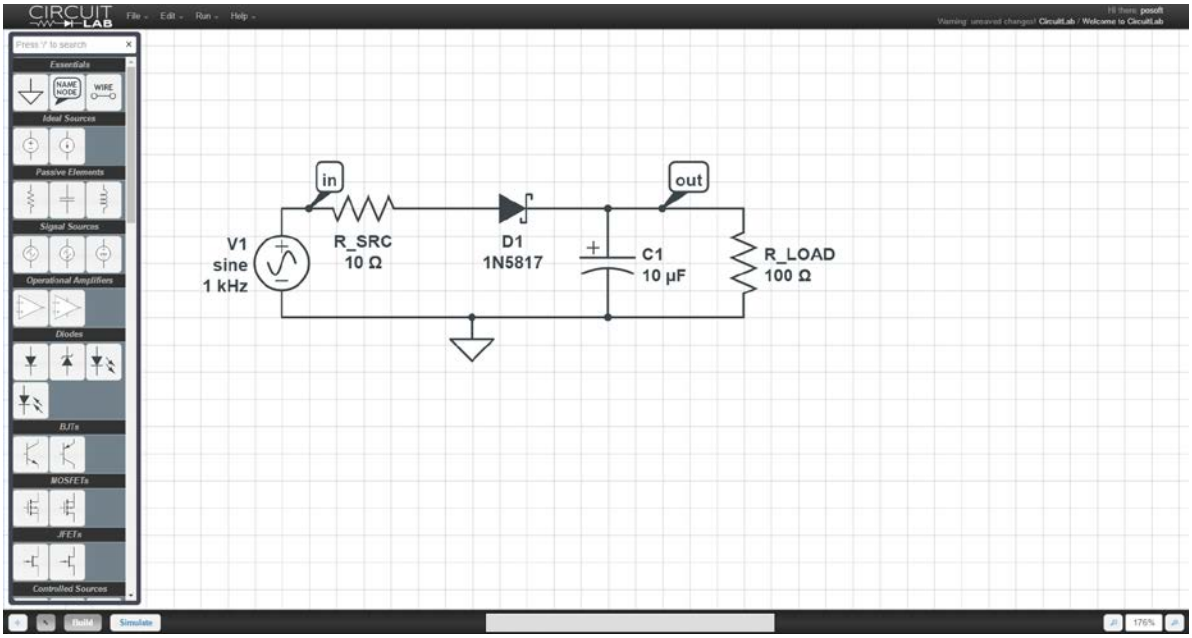

Figure 1. Circuitlab.com interface

There are a number of free circuit simulators available online. This online software has almost all the essential functions offline software had and allows students to study any time of the day. Students can save their work and continue the work at a later time. Some of them allow users to share their works with the community which provides questions and answers. Students can obtain more insight learning from others' work and read comments and explanations about a particular type of electronic circuits.

Wolfram Demonstrations

Wolfram Demonstrations is the largest collection of free, open instructional applets. It is an interactive visualization of a concept[3]. As it shown in Figure 2, the user can change the input and can see a change in its output that helps students understand the concept without requiring any additional work. Instructors can use them in the class to explain concepts difficult to teach or share with students to help them understand concepts better and faster during their studies. Also, instructors can develop their demos with a little bit of Mathematica coding knowledge. Wolfram provides all necessary tools to ease the applet development process.

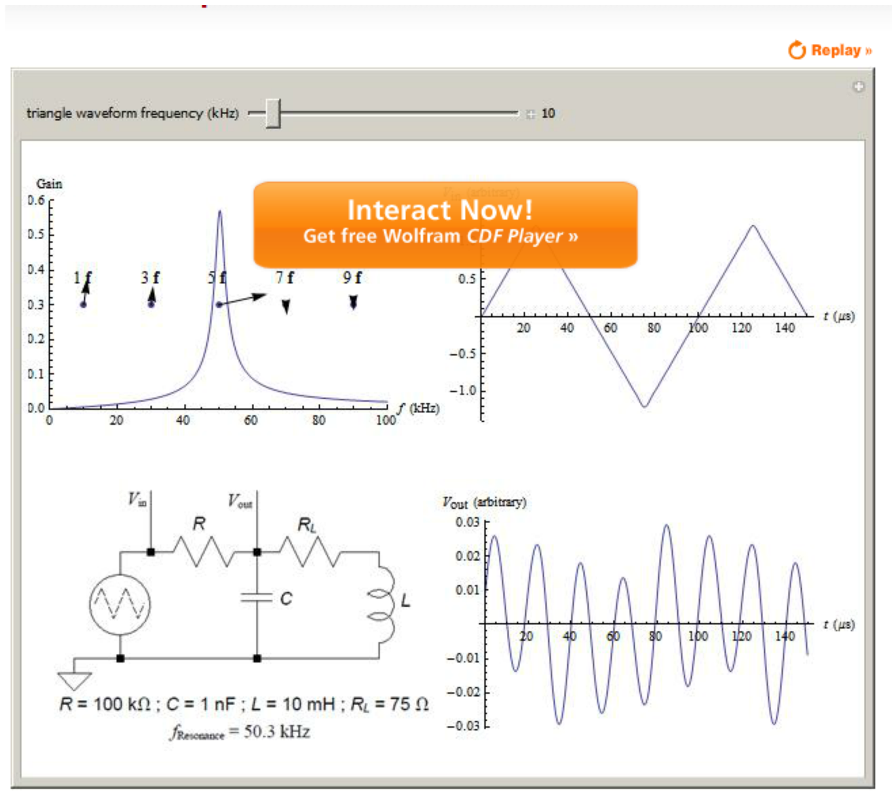

Figure 2. Example of Wolfram Demonstrations

High quality 2D/3D animation videos

Some of the electronic circuit topics are difficult to explain and understand within a short period such as working principles of the transistor, transformers, electric motors, and generators. There are numerous high-quality 2D/3D animations shows how these systems work. Using these animations during the lecture allows the focus on explaining principles instead of describing the physical construction of the device. It lowered the course instructor's anxiety on having to depict the device. It also enables better communications with students. Since it reduces the time required to explain the concepts, this enables the course instructor to ask more questions to cultivate insights by exposing new relationships.

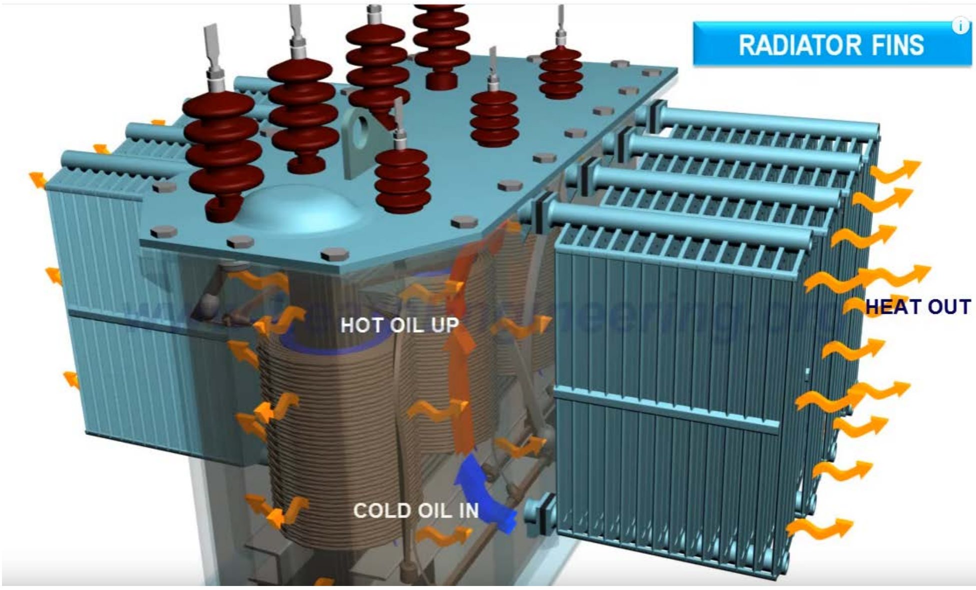

Figure 3. Example of 3D Animation of 3-Phase Transformer

Analog Discovery Kit

Laboratory equipment required for the course can be divided into two groups: software and hardware. Typically, most traditional laboratories have circuit simulation software such as National Instrument Multisim, and PSPICE[4]. As mentioned earlier, students can either install this software to their personal computers if school license permits them to do, or they can use free online circuit simulations software such as circuitlab.com or docircuits.com from their PC, laptop, or tablet. Thus students are not constrained with school lab to do circuit simulation lab or assignment[5]. However, essential hardware equipment needed to perform labs such as an oscilloscope, multimeter, DC power supply, and basic electronic components such as resistors, inductors, capacitors, and semiconductors were available to students only on campus during the lab time or limited open lab hours. Today, students can have all these lab equipment in a cheap, compact device. Even though there aa few numbers of these devices from different manufacturers, Analog Discovery kit from Analog Devices is providing best overall value due to its low cost, very small size, free software and good performance.

The heavy content of Introduction to Circuits course for non-electrical engineering force instructors sacrifice either from the coverage of the course content or number of lab experiments done during the semester. Using Analog Discover module with well-prepared lab manual, students can conduct lab experiment anywhere they want and anytime they want.

Piazza

Piazza is wiki style format enables collaboration in a single space. The instructor can create a course and add all the students in the course easily. It has LaTeX editor, highlighted syntax and code blocking. Students can ask questions or post their feedbacks. Questions and posts needing immediate action are highlighted to help the instructor. The instructor can endorse answers to keep the class on track. It allows anonymous posting to encourages every student to participate.

It has highly customizable online polls to get immediate feedback from students about their learning. Almost all universities use LMS tools, but most of them do either do not have some of the functions Piazza has or their user interface not as good as Piazza. Piazza integrates with every major LMS. It has excellent application for mobile devices which allows students to access all the materials anytime and anywhere they want. The instructor can clone the course and keep all the discussions from previous semesters which will enable students to find the answer to some of their questions from previous years postings by a simple search. Most students in my class indicated that they liked this feature because it allows them to find answers to some of their questions without asking the instructor, classmate or searching online.

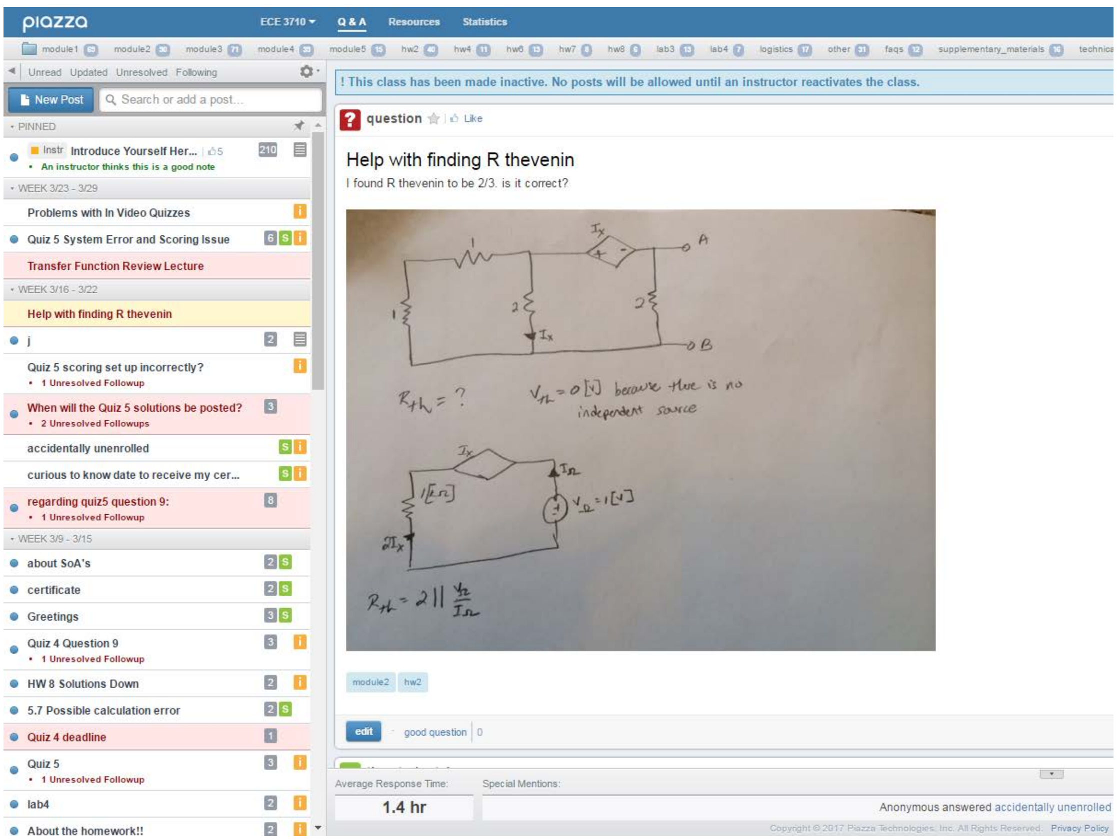

Figure 4. Piazza Application Screenshot

III. Results and Discussions

The instructor used all the tools mentioned above when the course was being taught the second time. Table 1 shows tools used in which subjects. There were 21 students in the class. All of them submitted course evaluation. Student course evaluation raised from 2.4/4 to 1.8/4 (1 is the highest and 4 is the lowest score). The pre-lab assignments were added which includes circuit simulation and questions related to circuits instead of asking students to do both circuit simulation and breadboarding during on-campus lab. Overall, the quality of lab reports had improved. There was no significant negative feedback about the laboratory exercises. Even though most students appreciate the tools I used, few complaints were observed that there were insufficient guidance and tutorials provided to help students using the tools when they needed. Since students were able to do some of the hands-on labs and all the simulations during the class period, the course instructor was able to cover almost all the topics included in the course description.

Table 1. Course structure and tools used for each topic covered in the course

	Lecture	Lab on Campus	Circuit Simulation	Take Home Lab	Wolfram Demos	2D/3D animation
Linear Circuits	Definition, KVL, KCL, Series & Parallel Resistances, Ohm's Law, Power	✓	✓	✓	✓	
	Voltage and Current Sources, Measuring Devices	✓	✓	✓	✓	
	Node Voltage, Mesh Current, Superposition		✓		✓	
	Thévenin and Norton Equivalent Circuits		✓	✓		
	Time Dependent Signal Sources					
	AC Signal / Phasor Analysis	✓	✓	✓	✓	
Analog Electronics	First Order Differential Eq. L & C, Transient Analysis		✓	✓		
	Operational Amplifiers and Diodes	✓	✓	✓	✓	
	Bipolar Junction Transistors		✓	✓	✓	✓
	MOSFETs		✓	✓	✓	✓
Digital Electronic	Binary Number System, Boolean Algebra, Logic Gates		✓			
	Combinational Logic Modules	✓	✓	✓		
	Sequential Logic	✓	✓			
Ele	Electrical Transformers	✓	✓	✓	✓	✓

	Electrical Motors and Generators		✓		✓	✓

IV. Conclusion

In this paper, we have introduced new technologies that can be used for teaching electrical engineering courses for non-electrical engineering students in order to enhance student engagement, have more hands-on laboratory experience and improve the understanding of core concepts. Overall, feedback from students about the new tools embedded in the course was positive. More work needs to be done regarding helping students to learn these tools fast. Otherwise, new technologies can be a roadblock to teach the actual content of the course.

References

[1] Flikkema, P. G., Rhonda, F. R., Frolik, J., Haden, C., Ohta, A. T., Shiroma, W. A., . . . Weller, T. (2015). Engaging Fundamentals and Systems Engineering in Introductory Circuits. *ASEE`s 122nd Annual Conference $ Exhibition.* Seattle: ASEE.

[2] Lei, C.-U., So, H.-H., Lam, E., Wong, K.-Y., & Kwok, R.-K. (2012). Teaching introductory electrical engineering: Project-based learning experience. *IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012*. IEEE.

[3] Wolfram, C. (2009, July 13). *5,000 Demonstrations: The Time to Go Interactive Is Now.* Retrieved from Wolfram Blog: http://blog.wolfram.com/2009/07/13/5000-demonstrations-the-time-to-go-interactive-is-now/

[4] *Hands-on learning with Analog Discovery*. (2015, 10). Retrieved 10 12, 2016, from ANALOG DEVICES: http://www.analog.com/en/education/university-engagement/analog-discovery-design-kit.html

[5] Shayesteh, S., & Rizkalla, M. E. (2016). New Modes of Instructions for Electrical Engineering Course Offered to Non-. *ASEE`s 123rd Annual Conference & Exhibition.* New Orleans: ASEE.