Hands-on Learning for Engaging Freshman Students through the Electrical Engineering Practicum and the Infinity Project

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ABSTRACT

The Infinity Project kit and the Electrical Engineering Practicum have been used to provide hands-on learning for Electrical and Computer Engineering students in a freshman course. The strengths and limitations of the two tools are discussed. The assessment results indicating the satisfaction of the students with the Electrical Engineering Practicum have been provided.

1. INTRODUCTION

It is known that a large percentage of students in engineering programs switch their majors in the first two years. One reason given for students switching to other majors is that the teaching method of "lecturing and note taking" is not suitable to the current populations of students who learn and acquire new knowledge quite differently from those of earlier generations. Several new pedagogical paradigms have been proposed to improve engineering education, such as the use of "hands-on" tools to change the teaching style in the engineering classroom to more engaging teaching pedagogies. Some approaches that have been used to engage and inspire electrical and computer engineering freshman students are the use of the "Infinity Project" and the "Electrical Engineering Practicum." This paper will compare and contrast the experiences of freshman students who used the two previously-mentioned tools for learning basic electrical and computer engineering knowledge and skills.

2. INFINITY PROJECT

The Infinity Project [1] is a multimedia hardware and software system for converting standard PC's into easy to use modern engineering design environments. A PC with the Infinity Project kit is capable of wide array of "real-time" engineering applications ranging from audio, image and video processing. The pre-designed lab experiments allow students to have experience in envisioning, designing and testing modern technology. The technology used in the Infinity Project kit is based upon Texas Instruments Digital Signal Processor (DSP) chips and the National Instruments LabView. The Infinity Project kit is shown in Figure 1. The Infinity Project has been used to increase the retention rate of freshman students [2, 3].

The course at Prairie View A&M University (PVAMU), ELEG 1021 Fundamentals of Electrical and Computer Engineering, was formally introduced in Fall 2003. To support the freshman class, the Infinity Project kits were purchased to build the necessary laboratory facilities at PVAMU. The typical experiments that were performed using the Infinity Project kit are shown in Table 1. The class used a textbook developed by a group of educators and engineers [4]. The

Infinity Project was used for the course ELEG 1021 from 2003 to 2014. From 2015 to the present, the ELEG 1021 course is using the Electrical Engineering Practicum.

Figure 1: Infinity Project Kit (From [2])

Table 1: The Infinity Project Experiments and Other Activities Performed in ELEG 1021

WEEK	TOPIC	CHAPTER IN TEXTBOOK
1	Introduction, Course Syllabus and Lab Tour	n/a
2	Team Dynamics Lecture	n/a
3	Ethics Lecture	n/a
4	Ethics Case Study Analysis	n/a
5	Testing Your System (Camera and Microphone)	1
6	Generating Sines and Cosines	2
7	Listening to Sines and Cosines	2
8	Midterm Exam	n/a
9	Plots of Speech	2
10	Echo Generator and reverb	2
11	Image Quantization	3
12	Early registration and academic advising	n/a
13	Sharpening Images	4
14	Touch-tone Telephone	7
15	Final Exam	n/a
16	Final Exam	n/a

3. THE ELECTRICAL ENGINEERING PRACTICUM

The Electrical Engineering (EE) Practicum is a cloud-based book [5] with experiments that uses the Analog Discovery module and electronic parts kit to facilitate hands-on learning and self-exploration by the students. The Analog Discovery module enables students to quickly test real-world functional circuits anywhere and anytime with their own personal computers. The Analog Discovery module has proven to be effective in motivating engineering students to study

foundation courses [6]. Several Universities, using other portable instruments, have had success in motivating and engaging students to learn engineering principles [7, 8, 9, 10].

The Analog Discovery module was developed by Digilent in conjunction with Analog Devices, Inc. The module communicates to a computer through USB interface. The operating software, WaveForms, can be downloaded free from Digilent website [11]. The module contains a two channel voltmeter, two channel (5 MHz) oscilloscope, two channel waveform generator, 16 channel logic analyzer, and 2 fixed (+/- 5 V) dc power supplies[11]. The operating software, WaveForms, provides all instrument functions and measurement results. The Analog Discovery kit is shown in Figure 2.

Figure 2: Analog Discovery Kit

The ELEG 1021 classes at PVAMU are using the textbook developed by Dr. Robert Bowman [5]. The typical experiments that were performed using the Electrical Engineering Practicum textbook are shown in Table 2.

The Electrical Engineering Practicum provides the students the laboratory skills, and also allows the students to explore and experiment in the areas of (i) circuit analysis, and (ii) electronics. In the area of basic circuit analysis the students learn: (i) Ohm's Law, (ii) voltage divider rule, (iii) current divider rule, (iv) charging and discharge of a capacitor of RC circuit, (v) resonant RLC circuit.

The EE Practicum also introduces the students to basic electronics such as: (i) semiconductor diodes and LEDs, (ii) half-wave rectification, (iii) Op Amp inverting and non-inverting amplifiers, (iv) envelope detection circuit. The students also experiment with electronic sensors such as: (i) TMP01 Thermal Sensor, (ii) ADXL237 Accelerometer, (iii) GT0950RP3 Speaker and ADMP504 Microphone.

Table 2: EE Practicum Experiments and Other Activities Performed in ELEG 1021

WEEK	TOPIC	CHAPTER IN TEXTBOOK
1	Introduction to Electrical Engineering, Lab Instruments, Procedures, Personal Test Lab	1
2	Power Supplies and Electrical Power	2
3	Signal Generators and Waveforms	3
4	Resistors and Ohm's Law	4
5	Diodes and Rectification	5
6	Capacitors and Time Constants	6
7	Inductors and Resonance	7
8	Mid-semester Exam	n/a
9	Thermal Sensors and Temperature &	8
10	Accelerometers and Tilt Sensing	9
11	Microphones and Sound Sensing	10
12	Radio Frequencies and Amplitude Modulation	11
13	Radio Frequencies and Amplitude Demodulation	12
14	Amplifiers and Sound Amplification	13
15	Professional & Ethical Responsibility	n/a
16	Final Exam	n/a

With regard to the laboratory skills mastered in the class, the students are able to : (i) read resistor values by using resistor color code, (ii) build electrical and electronic circuits using breadboard, (iii) use virtual instruments, such as arbitrary waveform generator, scope, power supply, voltmeter, network analyzer, and (iv) obtain Bode Plots by using network analyzer.

4. COMPARISONS BETWEEN THE INFINITY PROJECT AND EE PRACTICUM

The Infinity Project is a DSP-based hands-on tool, which is focused towards digital signal processing of digital music, audio signals, and image processing. On the other hand, the EE Practicum is more focused on the use of the Analog Discovery module for electronics and circuits experimentation. Table 3 shows the strengths and limitations of the two hands-on tools.

Table 3: Comparison between the Infinity Project and EE Practicum

Feature	Infinity Project	EE Practicum
Coverage of basic signals (sine wave, square wave, etc)	Yes	yes
Digital Image Processing	Yes	no
Communicating with ones and zeros	Yes	No
Teaches basic laboratory skills, such as bread-boarding, reading resistor values, and troubleshooting.	No	yes
Uses virtual instruments such as scope, signal generator, Network Analyzer, voltmeter	No	yes
Discusses basic circuit analysis tools such as Ohm' Law, voltage and current division.	No	Yes
Explores basic electronic devices and circuits	No	yes
Explores the use of sensors such as accelerometer, temperature transducer, microphone, speaker	No	Yes

5. ASSESSMENT RESULTS

The students who have completed the course did surveys. The survey instrument with the composite results for fall 2014, spring 2015 and fall 2015 semesters is shown in Table 4. The table shows the number of students who responded to each category in the survey instrument statements. For the fall 2014 semester, there were 12 student who completed the survey, 20 students in the spring 2015 semester and 17 students in fall 2015 semester. Table 5 shows the average results for the three above mentioned semesters.

Table 4: Survey Instrument and Results Showing the Number Respondent for All the Three Class Offerings

Item #	Statement	Strongly Agree (5)	Agree (4)	Neither Agree nor disagree (3)	Disagree (2)	Strongly Disagree (1)	Average
1	I learnt how to build circuits.	24	18	4	2	1	4.27
2	I learnt how to use scope, signal generator, and voltmeter of the ADM	30	11	7	0	1	4.41
3	I am satisfied with what I learnt in this class.	23	19	3	2	2	4.20
4	I will recommend this course to someone else.	33	8	7	0	1	4.47

Table 5: Survey results (Averages of Items) for three semesters, Fall 2014, Spring 2015 and Fall 2015.

#	ITEM	Fall 2014	Spring 2015	Fall 2015
1	I learnt how to build circuits.	4.42	4.30	4.12
2	I learnt how to use scope, signal generator, and voltmeter of the ADM	4.58	4.35	4.35
3	I am satisfied with what I learnt in this class.	4.00	4.30	4.24
4	I will recommend this course to someone else.	4.75	4.40	4.35

It can be seen from Table 4, in all the four areas surveyed, the averages for all the categories were greater than 4.0. It should be noted that "4" correspond to "agree" with the survey statement, and "5" to "strongly agree" with the statement. The highest of the averages was 4.47 corresponding to the students being willing to recommend the course to other students. Table 5 shows that the averages of the four listed items were higher for fall 2014 semester that the averages for spring 2015 and fall 2015, with exception of item #3 statement ("I am satisfied with what I learnt in this class"). The fall 2014 class was a pilot class with a small number of students.

The preliminary results seem to indicate that a small class size might produce better survey results.

In addition to the survey, some students provided positive comments on the Electrical Engineering Practicum. Some of the comments are: (i) "the hand-on aspect of the course was excellent," (ii) "the microphone and sound sensing experiment was fun," (iii) "I liked exploring the world of electrical engineering through the course," and (iv) "I liked the ADM and bread-boarding."

6. CONCLUSIONS

In order to improve retention of freshman students, the Infinity Project kits and the Electrical Engineering Practicum have been used to provide hands-on learning for students. The Electrical Engineering Practicum is currently being used in our freshman course because it is a tool that allows our students to learn basic laboratory skills, to be introduced to basic circuit analysis tools, and to experiment with electronic devices and electronic circuits. Assessment results and comments from students show that the experiments performed by the students, using the Analog Discovery Module in the Electrical Engineering Practicum, engaged the students through hands-on learning, and provided the students with solid introduction to basic circuit analysis tools and electronic devices.

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