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A Freshman Instrumentation Lab

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Abstract

Northeastern University introduced a freshman Instrumentation Lab into its Engineering Technology Curriculum in the fall of 1999. This lab is modeled after the freshman laboratory experience developed at Drexel University and in the initial quarter the first eight experiments from the Drexel Lab were used. Internet delivery was used to guide the students through the experiments. These experiments introduced basic measurement skills including both electrical and mechanical measurements. Purpose of the lab was to:

- Provide students with a Hands-on Experience;
- Develop self learning skills;
- Develop Critical Thinking Skills;
- Provide a basis to help them decide between the Electrical Engineering Technology, Mechanical Engineering Technology, and Computer Technology programs offered at Northeastern University.

Described in this paper are the experiments, the delivery at Northeastern, and an assessment of the lab effectiveness.

1. Introduction

In January of 1999, six faculty members from the College of Engineering visited Drexel University to review their pioneering freshman program, including the instrumentation lab. Their curriculum and the lab is described in Reference 1. In the lab, each workstation is equipped with a digital multimeter, power supply, function generator, oscilloscope, and computer. All instruments are computer connected using the HPIB (Hewlett Packard Instrument Bus). The experiments are all located on the internet at the Drexel site[2] and available in a published text[3]. Students enter the lab (with no preparation), perform the experiments as outlined on the internet site, and complete a quiz at the end of the lab. They are then done with the experiment with no homework or further data analysis required.

Representatives from the School of Engineering Technology were impressed with this laboratory experience. We saw it as an opportunity for the students to obtain hands on experience before they had to decide on their major (Northeastern University offers Computer Technology, Electrical Engineering Technology, and Mechanical Engineering Technology programs with the students selecting their major in the sophomore year). We also saw it as an opportunity to implement some of the ideas in our Academic Common Experience (ACE) program. The ACE program at Northeastern University is a novel approach to teach students in all majors basic core material that is common to all fields. Specific ACE values that the students would practice in this lab include developing self-learning skills and critical thinking skills. Introducing them to new technologies through the readings on the Internet and performing experiments in the lab, not through the traditional lecture, would develop self-learning skills. Critical thinking skills would be developed by requiring the students to think about what they did in the lab, consider the implications, and extend the results to other situations.

With these thoughts in mind, we decided to implement the instrument lab in our freshman Engineering Technology Program. Our plan was to complete eight experiments from the Drexel site in the fall quarter and an additional eight experiments in the spring quarter (Northeastern University is on the quarter system with each quarter being 10 weeks long). Initial implementation occurred in the fall of 1999 using an existing electrical engineering laboratory. The facility includes nine workstations equipped with a Tektronics oscilloscope, a Keithley multimeter, a Power Systems power supply, and a Tektronics function generator. In the summer of 1999, computers were installed at each workstation along with connections to the internet for each computer.

Figure 1: The Northeastern University Instrument Lab

2. Initial Implementation of the Instrument Lab

Initial implementation of this instrument lab was in the fall of 1999. For this initial course we used the first eight experiments from the Drexel Site. These first eight experiments are:

1. DC Voltage and Current: Uses a digital multimeter to measure the potential difference, voltage, and current in batteries, circuits, thermocouples and a solar cell.

2. Resistance: Uses a digital multimeter and Ohm's Law to measure resistance. Also uses a DC power supply and includes plotting and interpreting characteristic current-voltage curves.

3. Parallel and Series Circuits: Investigates current flow in series and parallel circuits and Kirchoff's Law. Also involves calculating equivalent resistance and building series, parallel and combination circuits. Demonstrates use of a Wheatstone Bridge.

4. Network Theorems and Devices: This experiment presents Thevenin's Theorem and the Maximum Power Transfer Theorem. Students construct circuits based on these theorems and then conduct experiments to verify these theorems.

5. Force, Length, and Mass I: Experiment presents measurement terms such as uncertainty, error, hysteresis, accuracy, mean and standard deviation. Students measure length and determine the accuracy of specified instruments. Students also analyze data and construct a histogram.

6. Force, Length, and Mass II: Students use a strain gage to measure voltage and weight changes for various objects. Students also calibrate and use different scales to measure mass, and analyze data on a spreadsheet.

7. Time Varying Signals I: Introduces the terms magnitude, frequency, period, amplitude, and root mean square voltage. Students use a function generator and an oscilloscope to measure AC voltage, period, RMS values and frequency of sine, square, and triangular waves.

8. Time Varying Signals II: With an understanding of time varying signals I, students measure the relationship between amplitude and effective value for AC voltages. Students also verify Kirchoff's Law for AC circuits.

The first four experiments were accessed directly from the Drexel internet site. For the second four experiments, changes were required in the write-up to reflect our different equipment and setup. Hence, the original write-ups were modified and loaded individually on the computer at each workstation. Modifications to the original write-ups were minor reflecting equipment changes only, not a change in objectives or tasks in the experiment.

The course was required of all our incoming (first quarter) freshman students. We had 92 students registered in the course and six sessions of the lab were offered. The course was offered on a pass-fail basis with the grade based solely on the exit quiz taken by the students at the end of the lab. No preparation was required by the students and no post lab work was required.

Figure 2: Students performing the sixth experiment in the lab

One addition we did make to the Drexel program, however, was to require the students to maintain a laboratory notebook. This was implemented to start them into the practice of keeping a laboratory notebook to record their work in the lab.

For proctoring in the lab, a graduate student Teaching Assistant was responsible for the students in the lab and conducting each lab period. He was assisted, in each lab, by an upper class Engineering Technology student (a junior year student). Three different students were used to proctor these labs. Additionally, School of Engineering Technology faculty were actively involved with the labs. Two different faculty members were responsible for different sections of the lab. They prepared the experiments and supervised the student proctors. A faculty member was in the lab for at least one hour during each of the lab sessions. Additionally, other faculty members stopped by the lab at least once a week to see how it was going.

3. Laboratory Evaluation

Overall the lab went well. Students worked diligently in the lab and completed their experiments within the allotted time period. Makeup labs, originally a concern of the authors, were not a problem. Few students missed labs and one extra workstation was available in the lab for each of the six lab periods a week for students to makeup a missed lab.

A student evaluation of the lab course was conducted at the conclusion of the course. Overall, the students gave the course a “B”. They found the hands on features of the course very interesting and fun. However, there was some disparagy in the remarks here. About ten percent of the students implied that this lab was totally duplicative of things they had done in high school. Another twenty percent indicated that the material was totally foreign to them and too complex. Thus it appears that the overall complexity of these labs was appropriate for the Engineering Technology students. This is an interesting observation since the labs were developed for Engineering Students. Overall, the complexity of the labs was rated a “C”, neither too complex nor too simple. However, the standard deviation of the students was wide, meaning there was disagreement among the students.

The students rated the lab as organized and well run. This really rates the structure of the Drexel program. They also indicted that the experimental write-ups were good. However, they indicated that the directions and explanations were frequently unclear. Hence, for use in engineering technology programs, it would be wise to expand the write-ups available from Drexel.

Many students also suggested that lectures be provided before each lab to introduce the material and the procedures of the lab. This, in the authors’ opinion, would defeat the purpose of the lab course. One of our goals was to show the students that they can learn on their own and that the laboratory is a learning place -- the lecture hall is not the only place to learn. It is hoped that expanded write-ups will alleviate the students’ desire for a lecture. However, at Rensselaer Polytechnic Institute they were able to implement lecture periods without removing these aspects of the lab. They used a one hour lecture each week where the first half of the class was devoted to reviewing the principles that they students learned in the previous lab and the second half presented material for the next lab. “New material was kept intentionally kept at a minimum so that some aspects are left for discovery in the lab.”[4]

Using upper class students as laboratory proctors was an experiment at Northeastern University. In the past, only graduate students were used as lab proctors. This was very well received by the students. They rated the student proctors a “B+” and recommended that the practice be continued.

4. Future Plans

We plan on continuing this instrument plan at Northeastern University. The next implementation will be in the spring of 1999. This will be for the same group of students who took the lab this fall. The plan will be to do eight additional experiments from the Drexel suite of experiments. Changes we plan on making to these experiments include expanding the write-ups to include more background explanation, and clarify the procedures, especially where our procedures may differ from those used at Drexel. Weekly one-hour lectures will also be incorporated into the course. Additionally, we will be installing A/D cards in the computers and will have at least one experiment built around using this capability.

We again plan on offering this course next year. Besides implementing the changes mentioned above, we have a number of other changes contemplated for the lab. One will be to change a few of the experiments. Specifically, six of the eight experiments are electrically based and the other two mechanically based. We want to make the balance more equal and provide more interesting mechanical experiments.

5. Conclusions

We are very pleased with the implementation of the instrument lab into the engineering technology curriculum at Northeastern University. Specifically we find that it:

- Provides the students with a Hands-on Experience;
- Develops self learning skills;
- Develops Critical Thinking Skills; and,
- Provides a basis to help them decide between the Electrical Engineering Technology, Mechanical Engineering Technology, and Computer Technology programs offered at Northeastern University.

The students agree with this assessment.

Bibliography

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