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Freshman Experiences in the Electronics Lab: Comparing the Approaches at the Polytechnic University of Catalonia (Barcelona, Spain) and Penn State University, Wilkes-Barre Campus

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ABSTRACT

It is widely recognized and accepted that the first electronics laboratory experiences for Engineering and Engineering Technology students are critical to establish good laboratory practices, develop their interest and curiosity in the subjects being taught and overcome the sense of fear that some students might have to use electronic instrumentation. This paper examines how two institutions, one in the United States, Penn State University, Wilkes-Barre Campus (PSU-WB) and the other one overseas, Polytechnic University of Catalonia, Barcelona, Spain (UPC) address the contents and the structure for a freshman electronics laboratory course.

The traditional approach for an electronics laboratory course is based on making students to build different electrical circuits with more or less help from the workbook or the instructor in order to verify the concepts explained during the lectures. Newly developed approaches take other factors into consideration to increase the student's interest and to facilitate the learning process. Some of the issues explored in this paper include: How to incorporate non-traditional support material such as catalogs and data-sheets into the classrooms, the integration of several experiments into mini-projects, the integration of measurement science into the lab work, and to stress the importance of not only designing and building a circuit that works according to the specifications, but also the need for the student to sell his or her product to a potential customer, in this case the instructor. All these issues will be examined at the light of the experiences at both institutions.

INTRODUCTION: THE GOAL OF LABORATORY EXPERIEMENTS

Laboratory experiences are a key factor in the success of an Engineering Technology Program. They provide the students with the opportunity to corroborate what they learned in the classroom, allow the instructor to introduce new material that will be later analyzed theoretically in the lectures and give the students a good view of what kind of work the professionals in their field do. Some of the programs in academia, in particular some Engineering programs, have a lack of laboratory work in the students freshman year, what stops them to become involved in a particular field. Because of their time limitations, and their industrial focus, Engineering Technology programs have solved these problems, by introducing in their freshman year laboratory work that in addition to support theoretical development, is fun for the students and reflects a current application in industry what helps to increase student motivation and their retention (Carlson et al., 1997).

The goals that we believe a freshman laboratory course should have are:

1) To make the students feel comfortable in the electronics laboratory. This laboratory course might be the first contact of students with a laboratory different from the ones that they worked on High School. It is full of instruments and equipment that the student has not seen before. Also, most of these equipment have several displays, control knobs, inputs, etc., what makes the student too feel at least afraid of them, and especially afraid of damaging the instrument through an error on their part. In this case, the students are afraid of the unknown. Our experience shows that the role of the instructor should focus on an explanation of the general safety guidelines for themselves as well for the instruments, emphasizing that it is acceptable to make an error provided this is not intentional. We believe that in this more relaxed atmosphere, the studentslearn better. Furthermore, as they progress in college, they tend to remember and focus on their experiences in the first laboratory experiments that they participated in (Richards et al., 1997).

2) To teach the students how to do basic measurements. A freshman laboratory course should consider different situations, and make the student to choose one particular instrument to perform that measurement. It is important that, as they progress in their studies, they have the basic knowledge on these type of measurements. We have found in different environments, that some students may experience problems in laboratory experiments in more advanced course due to a lack of knowledge on performing basic measurements. The role of the instructor should be in this case to present a situation, and guide the student towards the variables that will determine to choose one instrument instead of another one. The instructor should let the student make the ultimate decision, work on their instrument and later confront their decision. It should be emphasized at any time the characteristics of the chosen instrument that makes it more valuable and how they depend on a special application.

3) Replicate in the laboratory by experiences, the theoretical principles developed during the regular lectures. It is know that one picture is worth thousand words. This principle becomes increasingly important if they students have the opportunity the build that picture. It is not new that in Electronics, there is a high degree of abstraction in the lectures presented in the classroom, and some concepts can be more easily visualized and understood through practice. However, one needs to be careful with these experiments, being sure that the students have a good knowledge on how to interpret what they measure in the laboratory. Laboratory experiments should not be limited to collect data and later write a report. Students should be questioned during the laboratory period by the instructor on the physical meaning of what they just did and how it relates to concepts developed previously. It requires good synchronization between lectures and laboratory and a good coordination between the instructors for both academic activities, or better the involvement of the same instructor in both situations.

4) Development of new concepts that will be analyzed in further detail in later lectures. If the

students are well prepared, keep a good pace in both, laboratory and lectures, it is possible to introduce experiments about concepts that have not been covered yet in the lectures. Once the students have the measurements, the instructor in the lecture session can use their findings to introduce new concepts, equations and formulas that explain their results. A potential problem of this situation is that as the students do not have a reference on what values to expect, it is easy that errors can be undetected. For this reason, it should be reserved for the most advanced courses in which the students have developed their critical thinking abilities. It also requires a strong involvement of the instructor on the setup, approaches and measurements done by students in the lab.

In this paper we present how these situations have been addressed in two well-recognized Institutions of Higher Education. The authors are Faculty involved in programs in Engineering and Engineering Technology. Dr. Lozano-Nieto has been involved in teaching activities at both institutions. We believe that the aim of the discussion can be extended to other Universities and to other programs in Engineering and Engineering Technology.

THE ACADEMIC ENVIRONMENTS

The Engineering Technology programs at the Polytechnic University of Catalonia in Barcelona can be viewed similar to the Baccalaureate degrees in Engineering Technology in the US, as they comprise 6 semesters of instruction. The goal of the experimental laboratories in Electronics in which we have been involved is basically to reinforce the concepts and methods that have been developed during the lecture period. It is important to note that the laboratory work for most of the courses has been written by the same Faculty that are involved in the teaching of the theoretical concepts instead of using a commercial workbook. Although this approach puts more pressure on the Faculty, it allows to keep a good and constant pace between laboratory work and lecture development. It also allows to stress those factors that the instructors might perceive as more critical for the student, in either way. Furthermore, this arrangement ensures a more close relationship between the concepts, terminology, symbols, etc, between the textbook and the workbook for laboratory experiments. We have realized that this arrangement helps the students in retaining the information given to them during the lectures, especially when they need to think and evaluate their work at the end of each experiment. The Wilkes-Barre Campus is part of the Penn State University Commonwealth College. In this paper, we focus on the technical programs at the Campus that are Electrical Engineering Technology (2 and 4 year degrees), Telecommunications Technology and Biomedical Engineering Technology, both with 2-year degrees.

It is very important that the laboratory component has a strong pre-laboratory work, in which the student needs to review the concepts developed during the lectures, look for new information and have a good overview about what they will be required to accomplish during the laboratory period. Normally, laboratory time is a limited resource, and it should be used to test the prototypes, perform measurements, evaluate circuits or devices, etc. Work such as previous calculations, tables with calculated values, searching for information on devices data sheets, even building the circuits should be done previously. In this sense, it is very important to emphasize this idea every time that we have an opportunity to do so, develop and enforce a policy of allowing to do laboratory work only after pre-lab work is completed, and especially to design laboratory experiments in such a way that it is necessary to have done the pre-lab work in order to move through the different steps, so the students recognize the need for such work.

Our experience shows that a very important concept, especially in Freshman laboratories in ET, is for the students to learn how to use and especially, to choose a particular instrument to perform a measurement. We have also tried to incorporate circuit simulators in the classroom. However, our experience makes us to conclude that one has to be extremely careful when introducing those tools in the first years of ET. We have noticed that once the students become familiar with such a tool, they tend to use it even to perform basic calculations and basic approaches to circuits that should be based on their knowledge and, most of the times, common sense. Instead, some students use mechanically simulation tools whose goals are not the analysis of such small problems. Furthermore, when using such tools in the classrooms, the instructors should emphasize the need for the user to critically evaluate the answer that has been obtained from the machine, and perceive it in the context of the circuit or system where it has been originated. In any case, we recommend to introduce simulation tools only the advanced courses where the students have shown a maturity on their knowledge and critical thinking abilities.

CONCLUSIONS

Freshman laboratory courses in Engineering Technology have a very strong impact in the future student performance and interest in the field of electronics. Being the first exposure to electronic instrumentation, these laboratory courses should be heavily oriented towards making the student to feel comfortable in the lab through their progression in the use of instrument and measurement techniques.

In addition to the technical contents, these courses should also emphasize other aspects of vital importance in the student’s careers: the importance of good writing skills, the importance of professional appearance, and the importance of selling a measurement, circuit, system to a potential buyer that in the case of academia is the instructor. Our experience in different laboratory settings for different curricula show that a key point to maintain the student’s interest in the field is to base the experimental contents on situations as much real as possible. Instead of just measuring parameters from several electronic devices, the laboratory experiments should try to “emulate”, taking into consideration the academic level of the students, the infrastructure, etc., situation that the students can relate to. Similar conclusions have been extracted for other engineering disciplines (Elizandro and Smith, 1997). As a matter of example, the freshman electronics laboratory in the UPC is structure in such a way that the different experiments that the students carry out are parts of a mini-project that is a house automation system

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