PRACTICAL CLASSES AND EXAMINATIONS ON BASIC ELECTRONICS LABS IN COMPUTER ENGINEERING

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Abstract *— This paper describes how the Computer Engineering students at UCDB are motivated in lab lessons and exams, to get more out of lab experiments, to better understand future classes but also aiming at their professional life after graduation They have to try the experiments with simulators on their own, before lab lessons, coming more prepared and participating more effectively on them. A practical exam was devised to measure their practical proficiency in using lab equipments and in using their intuition to better analyze and understand basic electronic circuits. The help of teaching assistants (TA) was used in part of the practical examinations to speed them up, but in a structured rigid way to avoid variability of criteria by the TAs. These were developed over the years of the course existence, resulting in an increase in the students confidence and interest also for theoretical lessons, having encouraged their initiative and group skills.*

Index Terms — evaluation, laboratory, basic electronics, instrumentation.

INTRODUCTION

When the computer engineering course at UCDB was first created, we seeked a balance between hardware and software aspects in our students formation. Therefore, several classes were designed to have both theoretical and laboratory lessons, with these serving as motivation and reinforcement of concepts covered concurrently at the theoretical lessons. This happened to programming classes as well as those involving hardware, including classes for electricity, basic electronics, digital circuits, computer architecture, computer networks and notions of telecommunications, to name a few. Based on the authors work experience in design of digital hardware, commercial and scientific software development, and network infrastructure and management, it was clear the profile the an employer would look for in a future engineer.

Hence, it was necessary that the student didn't get to the end of the course by just being approved by passing written tests of what had been seen in the lab experiments, or by repeating one of the experiments. It was necessary to develop autonomy, self-confidence and experience to use lab equipments such as multimeters, oscilloscopes, function generators (FG), power supplies and the like. Mainly, it was important to develop the student's creativity to let him use it later with confidence in later classes, and even more, to let him practice his intuition in solving daily problems, like debugging computer network cables and NICs (network interface cards). For example, it is important for a computer engineering to recognize when a network is done according to cabling standards, at least to assess hired third party contractors.

The lab classes and evaluations were not only on the authors' experience from their students days at FEI, Georgia Tech and USP, but also from the exchange of ideas with professors from other schools, and from books like Leach [5], Malvino [4], Capuano & Marino [8], Chui [7] and other examples at the reference section. After a few years applying this methodology, we found out that USA universities also applied similar exams, as seen in Webster [1]. Every year new ideas are added, improving the exams and trying to correct any faults.

GENERAL DESCRIPTION

At UCDB lab and theory are part of the same class, with the same joint grade. To force the students make an effort at the lab lessons, the grades are defined in such a way that it is almost impossible to pass the course without learning the lab techniques. The passing grade without extra exams is 70%. Between 40% and 70% there is another test to complement the grade. Therefore, we forced 30% of the whole grade to come from the practical activities. If the students choose to ignore lab lessons, they need 100% on the theoretical part, which is highly unlikely. And for 30% of the practical activities, 10% comes from experiment reports and 20% from a practical proficiency examination.

Also, in the first lab classes they see basic concepts and learn to use simulators, like Electronics WorkBench (now renamed to MultiSim) [1],[5] or PSPICE [8]. From then on, to attend lab classes the student is required to bring a simulation of the experiment, done before the class. This

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intends to make him try to understand the experiment before, bringing doubts, making better use of the professor and TA time at class, guaranteeing the completeness of the experiment during class time. We also intended for him to figure out that design problems can be debugged at a simulator, but a later practical assembling is crucial to handle practical problems, like assembling, noise, interference, etc. On the following week a report on the experiment has to be produced, one per bench, a team of three, with the grade emphasis being on the conclusions reached from the experiment.

For the remaining two thirds of the practical grade, a practical skill examination was created, so the student can show his abilities in using instruments and assembling basic circuits, as well as his qualitative understanding of the basic RLC and diode circuits.

It is not reasonable that a engineer graduates and could not, for example, use a multimeter to test on outlet voltage or not be able to test a network TP (twisted pair) cable, or still not being able to visualize the waveform of a modem or digital circuit. Flaws like that is what we try to avoid, trying to create an engineer who is not afraid to "get his hands dirty".

Simple instruments were chosen, more likely to be found on labs outside of universities. They were intentionally not automated by IEEE488 (or GPIB, general purpose interface bus, a network protocol for instrumentation), so the real skills of the students could be observed.

At its first edition, this exam proved to be too long to be given by a professor alone. Besides, there was a problem to keep the same level of exam throughout the long exam. The level should be the same for the first and last students, regardless of the teacher getting tired, or from one day to the next.

Starting on the second year of its application, the help of other students were used to speed things up. The TAs, or students from previous semesters who stood out, were used for the simpler parts of the exam, more direct and objective. The qualitative concepts were still managed by the teacher in charge.

WANTED KNOWLEDGE

The students receive a list of instructional skills to be done under supervision of a TA, shown partially on appendix 1, part of it was repeated on appendix2, and omitted here. The tasks are such as identifying resistors by color code, assembling series, parallel and mixed circuits, measurement of current, voltage and resistance, with both analog and digital multimeters, and the use of function generators and oscilloscopes. These are supervised and graded by the TA, with the teacher being responsible for the qualitative questions on behavior of circuits.

To let the exam have a rigid structured way, avoiding variability of criteria from one TA to another, a series of items to be checked was created. This list contains the 40 most common errors predicted to be made by a student, including connecting cables to multimeters (MM), and adjustments of MM, oscilloscopes and function generators, among others (refer to the appendix 2). A form to be filled by the TA was created, to better control and make grading easier (appendix 3). It contains the code for the possible errors on the lines, and the names of the students on the columns. Each wrong item takes 0.25 down the practical exam final grade.

To make it practical the students take the test in pairs, better described later on.

To check the competence of each pair, at each new pair the TA is oriented to randomly change components and adjustments of the equipments, like trigger, intensity, position, output level of the generator, ranges and so on.

As the years went by, suince the exam time is limited, the students started to practice in advance in the days before the exam, reviewing experiments and using the list of common mistakes as a study guide, as the minimum necessary, using the lab on its free off hours. There is no problem in letting them know this list, what will be asked, since what is asked is exactly what he is expected to know by the end of the semester, and later, after graduation. This way, we end up making them really get interested in using the lab off hours.

APPLING THE EXAM

As mentioned, to speed the tests up, the students are grouped in pairs, but with both being asked. If one of them does not know something, both of them loose the points of that item. With this, a solidarity atmosphere is formed, but without a weak student relaxing and leaving all the work to a competent friend. By the way, in 5 years applying this methodology, there has never been a non-homogeneous pair, of students with too different skills.

Three or four test benchs are assembled, with TAs applying the straight forward questions, and as each pair finishes, it waits to go to the teachers bench for the more subjective interpretative questions. Each TA writes down each pair mistakes on the form and randomly changes the settings and components for the next group.

The TA should not give any hints to the group, stopping them only to avoid mistakes that could damage the equipments, like burning a multimeter fuse, but still writing down this mistake. Initially this possibility was not foreseen, delaying the following groups because of having to stop for repairs.

Each pair has 20 minutes to execute all procedures, allowing up to 30 minutes but taking one point off in this case. After 30 minutes they should stop where it is to avoid exceeding the days reserved for the test.

The teachers bench is assembled with real or simulated circuits, like RLC in DC or AC, or supplied by square waves. Also half of full wave rectifiers can be used, having their behaviors analyzed and explained by the students. The teacher also asks for the identification of capacitors and diodes. After this, by changing the value of a component or characteristic of the injected signal, the group is asked to predict the behavior of the waveform. Or by showing a waveform they are asked what should have happened with the frequency or injected waveform or component values.

Each group is given different questions to different circuits, avoiding that in the waiting time a friend who has just done the test gives them tips.

The TA part accounts for 80% of the test, 20% is from the teacher, who assesses each student domain of the subject and gives the final grade of the exam test.

CONCLUSIONS

The use of simulators before lab lessons improved the use of the small time destined to them, but it was after the implementation of the described practical exams that we noticed a greater motivation of the students, even improving the learning of concepts given in the theoretical lessons. This way, the lab really reinforced concepts seen in theory.

The limited time of the practical exam forced the students go to the open lab to practice their skills and solve their doubts, increasing the percentage usage of the labs. The participation in class increased, as well as the students interest, and many students started to enjoy the practical aspects.

Although the effort was present in all experiments during the semester, it was at the end, when really asked for, that the students found out their capability of thinking on their own, increasing their self-steem and confidence.

We noticed a greater participation and pleasure in the all exam even by students who traditionally did not show interest or responsibility in solving lists of exercises, participating in theory classes or looking for a teacher or TA office hours to clear doubts.

By exchanging ideas with other university professors we felt the need to share these successful ideas on this paper.

The appendixes try to illustrate and help the accomplishment of similar ideas by whoever gets interested.

APPENDIX 1: DIRECTIONS THE STUDENTS (HANDED TO THEM)

Instructions:

The idea of this test is to measure your proficiency in using lab equipments, needed for the next semesters, as well as measure your intuition in understanding the behavior of some basic circuits. The student who fails an item lowers both students grades. Each wrong item counts for 0.25 of the total. You have 20 minutes to take all items. It can go to 30 minutes, but then one point will be discounted. At 30 minutes stop where you reached, the remaining is counted as wrong. The first 8 points are measured by a TA, the other 2 by the teacher, measuring your comprehension of some circuits. The TA will only stop you if there's a risk of damaging the equipment, but you still loose the item.

Procedures

The same as listed at appendix 2, the list of items to be done with possible common errors for the TA to grade. The list handed to student taking the test on appendix 1 obviously ommits the possible common errors.

APPENDIX 2: LIST OF ITEMS TO BE DONE AND OF RESPECTIVE COMMON ERRORS (FOR THE TA)

COMPUTER ENGINEERING – UCDB
BASIC ELECTROCNICS – practical evaluation

The student should know the items below. For each sub-item not known, decrease the total score.
The corresponding value is indicated on the table.

1. Identify the nominal values of 3 resistors (color code).
2. Assemble the mixed circuit in figure (1).

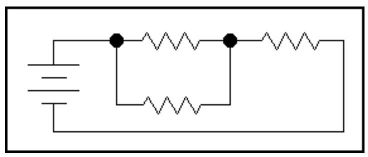

FIGURE 1

3. Measure R (resistance) and V (voltage) in each R with an AMM (analog multimeter).

a. tips should be inserted correctly in the MM (common=black, V/R red).
b. in AMM use the best possible range (with the tip in the middle of the display).
c. to measure resistance, R should be isolated from the circuit
d. at each change of R range, adjust the 0 (tips shorted).
e. read R multiplying the range position
f. read V in parallel to the element.
g. at each change of range of V, SHOULD NOT adjust 0 (tips shorted)
h. on AMM read in the proportional range, multiplying by factor 10,100, etc..

4. Measure I (current) in each resistor with AMM.

a. tips should be inserted correctly in the AMM (common=black, I(A) red).
b. in AMM use the best possible range (with the tip in the middle of the display).
c. I should be measured in series (break the circuit).
d. on AMM read in the proportional range, multiplying by factor 10,100, etc..
e. read the display value, with unity given by the chosen range (K, M...).

5. Measure R and V with DMM.

a. tips should be inserted correctly in the MM (common=black, V/R red).
b. in DMM use the best possible range (largest detail without exceeding the display).
c. to measure resistance, R should be isolated from the circuit
d. at each change of R range, it should NOT adjust the 0 (tips shorted).
e. read the display value, with unit given by the range (K, M...) (in DMM cannot multiply by the range)
f. read V in parallel to the element.

6. Measure I with DMM
a. tips should be inserted correctly in the DMM (common=black, I(A) red).
b. in DMM use the best possible range (largest detail without exceeding the display).
c. on DMM read the display value with unit given by the range (K, M...) (in DMM should NOT multiply by range factor)
d. at each change of R range, it should NOT adjust the 0 (tips shorted).
e. I should be measured in series (break the circuit).

7. Measurement with Osciloscope:
Connect the output of the function generator (FG) to the channels of the scope, with the FG with a sine or triangular wave, 100, 500, 1k or 5kHz, changing for each pair.
-.Read V and f (frequency).
-.Measure the sine RMS voltage DMM and compare to the scope's reading. (Vp/1.41).

a. adjust beam to horizontal central position.
b. adjust intensity a little under maximum.
c. adjust focus to maximum visibility.
d. adjust horizontal scan to have at most 2 cycles on screen.
e. adjust vertical deflection so the wave occupies 40 a 80% of the screen. (not too large nor too small)
f. adjust trigger to automatic.
g. knobs of vertical deflection, horizontal e trigger should be on calibrated position.
h. V should be measured in parallel, multiplying the divisions by the range.
i. should measure V peak and calculate Vrms=Vp / 1.41
j. measure period T (divisions x hor. sweep) and calculate frequency (f=1/T).
k. should know how to adjust the FG to sine wave and to choose output level and wanted frequency.
(CHANGE SETTINGSAT EACH NEW PAIR)

EXAMPLES OF QUESTIONS OF CIRCUITS FOR ANALISYS
8. Interpret the DC circuit behavior:
a. recognize the different types and values of capacitors and diodes
b. observe the division of current in parallel circuits and the division of voltage in series circuits.

9. Interpret the behavior or AC circuits (requires 2 channel scope).
a. observe the difference of phase between Vr and Vc to go down as the sine frequency goes up.
b. observe the Vcap in RC circuit, explaining why a square wave transforms into a triangular one by increasing the frequency (the period decreases, there's not enough time for the capacitor to totally charge and discharge it on dV/dT, but they hadn't seen that yet).

TIME:
a. the exam should last 20 minutes at most; up to 30 is allowed, but cuts 1 point from total;
b. If after 30 is not finished, interrupt and count only what is done, to avoid exceeding total number of days due to too many students. DON **NOT** EXCEED 30 MINUTES!

APPENDIX 3: EXAMPLE OF STUDENT CONTROL PER STUDENT (0.25 POINTS PER ITEM)

1							1
2							2
…							7j
7k							7k
8ª							8a
8b							8b
9a							9a
9b							9b

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