# A "Distance Education" Simulated Electronics Laboratory

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## INTRODUCTION

The State of West Virginia has a tradition of making it possible for citizens to commute easily to higher education from wherever they may happen to live in the state. This educational commitment means that the State College and University System supports many small institutions in remote parts of the state. It is becoming clear that the state can no longer afford to maintain the present system, especially when the demand for more and more specialized higher education is increasing in the rural areas. If we are to meet our mandate in a cost-effective manner, new ways must be found to deliver engineering classes to widely scattered students at home or at facilities which do not have engineering laboratory equipment. It is in this context that the department of Electrical and Computer Engineering has attempted to develop a quality electronics laboratory experience for place-bound and equipment-poor students.

## THE PRESENT COURSE STRUCTURE

The presently required traditional laboratory is entitled "Digital Electronics Laboratory." The catalog description is "*Design, fabrication, and measurement of digital electronic circuits. Use of discrete devices, integrated logic, display devices, and timer circuits. Study of A/D and D/A circuits and interfaces.*" The laboratory normally meets once per week for a semester. It is designed to accompany a 3-credit lecture course covering p-n diode-based, BJT-based, and MOSFET-based logic gate implementations, along with registers, counters, converters, memory, and microprocessors. Particular attention is paid to the relation between internal device characteristics and terminal behavior of IC's. The course is taught to second-semester sophomore students.

## THE DEMAND FOR CHANGE

Both the content and the timing of this laboratory and the accompanying lecture course are unusual within either an electrical or a computer engineering curriculum. Thus, many students who would contemplate transferring to WVU beginning with their junior year find that they are deficient, since the courses are difficult to find. In fact, they are taught nowhere else in the state of West Virginia. None of the other instructional sites in the state felt that they had enough students to justify offering the courses themselves. The department was therefore asked early on if the courses could be delivered by distance learning to students at other sites in West Virginia who planned to transfer to WVU.

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In Spring 1996 the lecture and laboratory were delivered to one remote site. This was done by video taping the classroom lectures of the campus-based course. Tapes were sent to the remote location several times a week, along with a complete set of class notes generated by a student in the class. The home-based instructor provided homework assignments and exams and quizzes by mail as well. A mechanical engineering instructor at the remote site coordinated the receipt and use of materials and administered the quizzes and exams. The laboratory was carried out by mailing the written exercise assignments to the remote instructor who made a laboratory room available to the students and assisted them as best she could in doing the exercises and design problems. Twice the home-based laboratory instructor (who was also the lecturer) traveled to the remote site for an afternoon of working with the remote students, and twice they traveled as a group along with the remote site instructor to the WVU campus to work in the laboratory.

While the students who participated in the peripatetic class and laboratory did as well as other students in the courses (received comparable grades), we did not believe that they had gained a level of laboratory experience comparable to the home-based students because equipment was limited at the remote site and the remote-site instructor could not provide much on-the-spot instruction in the laboratory. It is for this reason that we considered using the internet to deliver a laboratory experience which would not be limited by laboratory equipment availability or on-site instructor availability.

**DEVELOPMENT DETAILS**

During the Fall 1996 semester neither the lecture class nor the laboratory were scheduled to be offered. However, the department chair was approached by nearly a dozen students who wanted either the class or the laboratory or both. Given the desire to develop an internet-based laboratory and the unexpected demand for the laboratory from home-based students, the decision was made to develop the laboratory while offering it to home-based students only. Because several students needed the accompanying lecture class as well, the "distance learning" version of the lecture course using the video-taped lectures was offered also.

The students who had expressed an interest were contacted and presented with an explanation of what would be offered, and warned that difficulties were likely to occur as new techniques were being developed and tried. Three students chose to participate in both the laboratory and lecture, and one student chose only the laboratory.

Of the four students who participated in the developmental laboratory, three were doing so because they were "out of sequence" in their progression toward a degree because of illness or failing a course. The fourth worked full time locally and had been unable to schedule the laboratory. The first three were also taking the video-taped class, the fourth had already had it the semester before (in fact, he was the designated "note taker" who produced the class notes to be sent to the remote-site students). He was also a "non-traditional" student.

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Three of the four taking the laboratory considered themselves to be very computer literate (one owns a computer business and a second is employed as a programmer); the fourth had a computer and considered herself to be moderately literate. All said that they were looking forward to the experience.

## SEMESTER ACTIVITIES

The students purchased Electronics Workbench$^{®}$, which was delivered the second week of the semester. Their first assignment was to install the software and carry out several simple exercises to become familiar with the software and its capabilities. Soon I was informed by one of the students that she was unable to load Electronics Workbench onto her computer. I never heard from her again. The assignment included sending an EWB file to me. Two students were unable to attach the file to an e_mail message. The third did so, but I was unable to decode it (the students all were using PC compatible computers, whereas I use a Mac). I eventually got files from two students by having them deliver a floppy disc to me. The third student stopped responding about this time and sometime later I found she had dropped the laboratory from her schedule.

The second laboratory assignment was also to be done by each student independently. It was communicated to them via e_mail and required only an e_mail response to send a few key results rather than to send an EWB file. One student came to my office and asked to sit with me while he showed me what he was doing with EWB and some of the problems he was having. I received results from two students which indicated that they had been successful in completing this laboratory exercise. Both submitted their results late, however.

The third lab assignment was much more involved. The exercise itself was available on a web page that had been created for the course. Besides that, I sent an EWB file attached to the message which contained some "black boxes" that the students were to determine the electrical characteristics of in the laboratory. Only one student was able to read the file I sent. Another finally brought a disc to my office which I copied the file to. I had no response from the other two. Once again I had office visits from one of the students who wanted to sit together with me to show me what he was doing and ask questions about the results.

For the fourth lab assignment I asked the two remaining students to use each other's black box results to design simple circuits. I made them responsible for working together to determine where mistakes had been made and to correct them. This assignment was a disaster! I did not receive the results on the due date nor even a week late. We wasted about two weeks while I cajoled them to work together to complete this assignment, but they never did so. I finally gave up and moved on to another assignment.

The fifth assignment was once again an individual assignment. This time I was able to encode the file one way for one student and another way for the second student so that they could read them. One student did not finish by the end of the semester. The second student had questions, but rather than sending me an EWB file he chose to post the circuit

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that he had questions about to his personal web page.  I viewed it there and discussed it with him via e_mail.  He completed this assignment.


## SUMMARY OF STUDENT PERFORMANCE

Of the four students who began, as far as I know one was unable to ever load EWB into her computer.  A second student fell by the wayside early, apparently because of a combination of unwillingness to meet the challenge of learning the material and frustration with trying to learn to send files electronically.  A third student who started out quite strong and intensely interested in the laboratory slacked off at the end.  He told me later that he did so because he was having great difficulty with another course he had to pass.  The fourth student struggled at the beginning, and I thought I would lose him, but then he became interested in the material and came on very strong at the end.  I believe he would have done considerably more work had I made more individual assignments.


## STUDENT FEEDBACK

I interviewed at length the two students who finished the laboratory.  Their feedback was frank, and often quite helpful.  Many of their complaints were expected based on the kinds of difficulties we had.  Some of their responses which I found interesting are:

> • *"I wanted to see and touch the transistors, gates and other circuit elements that I was working with.  We should have at least one full day of 'hands-on' work."*
> • *"The instructor should be an expert on using the circuit simulation software as well as communication and file transfer techniques."*
> • *"Don't  make me work with a partner.  I want to show what I can do  alone."*
> • *"The instructor gave us too much flexibility by saying initially that we could work on assignments as long as we wanted until we got them correct.  We should have had an assignment due each week with no extensions."*
> • *"Don't build an assignment upon the results of a previous assignment."*
> • *"The instructor should provide detailed feedback on what the student did right and wrong.  Setting up situations where the student can observe whether or not the design worked without giving help about why things don't work is too frustrating."*
> • *"The simulation software should be available on the local network, and there should be a consultant available who can help with problems.*
> • *"The Electronics Workbench software is very easy to use.  I now use mine at work to help me design.  The instructor of the lecture class should incorporate it to illustrate concepts he is trying to explain."*
> • *"The instructor should INSIST that the students set aside regular times to work on this material."*
> • *"I would not take another class like this unless I was certain that it was very structured and well coordinated."*

**LESSONS LEARNED**

I found the entire experience to be difficult and not very satisfying, both from a personal standpoint and because of the high attrition and lack of productivity. I concluded based on my experiences and lengthy feedback interviews:

1. I did not allocate enough time to be able to fully meet the demands of the course. Since I had many exercises drafted, I believed that my time would be spent creating new exercises, assigning exercises, and checking the student's results. Instead, we spent a great deal of time dealing with software incompatibilities and bugs. This was apparently exacerbated by my using a Mac and the students using PCs, as well as their having a different e_mail program from the one I was using.

2. Meaningful technical discussions did not occur except in face-to-face meetings. This seemed to be due to a combination of difficulty in sending circuit files and the fact that the class was asynchronous -- the students worked at different times from each other and at times different from when I was available. The delays which resulted made interaction and collaboration difficult.

3. The students (and I) should have set aside specific times to work on the class, and have the discipline to do so. Without the structure imposed by the formally scheduled meeting times it is too easy to let things slide. I should have also had regular due dates for work to be submitted. I now think that having a detailed structure of requirements is a must.

4. Most sophomore students cannot be expected to work challenging laboratory design exercises without some real-time instructor interaction. They seem to need immediate feedback about how they are doing, as well as leading questions to help them solve their problems. Students asked to work as teams must also be able to "chat" some way in real time.

5. My students do not know how to work effectively at a distance, especially in a loosely structured environment. Apparently, it requires certain social skills to interact personally, other skills to interact by telephone, and still other skills to be productive by "letter," for that is certainly what e_mail amounts to. Specifically, they lack the skills to "compose" questions so that they can get maximum benefit from each asynchronous transmission.


**FUTURE PLANS**

Despite my frustration, I believe I can succeed and I do plan to continue to develop internet-based laboratory exercises, since I believe that it is imperative for us to find an effective way of providing this kind of experience at a distance. I will be working more on laboratories during Spring 1997. Changes I plan to make in my approach are:

• I am not going to ask students to work together closely on assignments. Since I am not prepared to put a great deal of effort into facilitating collaboration among students who

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are not skilled at such tasks, I will leave the job of developing student collaborative skills to other times and other places.

• I am going to impose a strict schedule of work.  I will have many small assignments due often.  I may even require that the students engage in a synchronous "chat" sessions with me once or twice weekly so that I can tell if they are working and how well they are learning.

• I will provide some sort of face-to-face interaction for the students.  If conditions prohibit me from meeting them personally, I will arrange to have an upper level student or some other knowledgeable person help them with the technical details of sending and receiving files and using Electronics Workbench.


## ACKNOWLEDGMENTS

## AUTHOR BIOGRAPHY

WILS L. COOLEY received degrees from Carnegie-Mellon University.  He has 29 years experience at CMU and West Virginia University, plus one semester at University of Hertfordshire in the UK.  He has taught engineering design at various levels for most of those years, and was sponsored by NSF to develop sophomore design materials.  Dr. Cooley is a Fellow of IEEE and a Registered Professional Engineer.