

Interactive Classroom for Experiential and Collaborative Learning

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Introduction. A major task to develop a new teaching laboratory for the Electrical and Electronic Systems (EES) was undertaken during Spring 2000. This laboratory is used by four courses in the Electrical and Electronic Systems area: Circuit Analysis, Electronics, Sensors and Transducers and Motors and Power Distribution. Each of these courses has a laboratory component. The original facility had limited space and equipment that required students to work in groups of four or five students. Typically, only one or two students actively participated in the assignment while the remaining students observed. During the exercises, the major goal of students was to finish as quickly as possible and leave the laboratory.

Recognizing the deficiencies in the laboratory and the desire to enhance a student's experience in experimentation, several features were identified that would be beneficial for the new facility. Each student should be able to actively participate in the hands-on learning exercise. Traditional instructional techniques limit the interaction between the instructor and student during the class session; therefore, the new facility should include technologies that would foster more direct interactions between the instructor and students.

Background. Many books and research articles have documented the different ways people learn. People learn new material through the processing of information that was captured by visual, auditory or kinetic means. Traditional instructional methods require students to learn by listening to lectures and reading material. Usually, kinetic learning methods involve laboratory exercises, homework assignments, and design projects.

Active and collaborative instructional methods for improving the learning process of engineering students have been published. Students exposed to active instructional methods developed improved problem solving skills when compared to students learning in traditional learning environments.^{1,2} These methods incorporate technologies such as wireless keypads that actively engage students during the lecture. The benefits of collaborative methods where students work on projects together is dependent upon the group dynamics.^{3,4} According to Darlin and McShannon³, traditional methods were successful for those students who generally are successful in engineering while the success for high-risk students increased when the interaction learning was conducted with the faculty member. Students can increase their problem solving and critical thinking skills when given an opportunity to witness how an expert approaches and solves a problem.⁵ Learning these skills requires a student to acquire expert knowledge,

recognize the existence of a problem and become aware of different strategies for approaching a solution. By mimicking an expert, students can begin to acquire and refine these skills.

Several papers have been published that describe different environments for students to learn through hands-on experiences. Hands-on learning methods challenge students to apply their theoretical knowledge for solving problems in a laboratory setting. The laboratory setting provides each student an opportunity to improve skills in problem solving through experimental exercises. Not only is the theoretical concepts reinforced, but the students have a higher retention rate of the lecture material. By trial and error, students have an opportunity to build confidence in their skills that enhance their ability to perform outside the academic environment. This approach also provides an opportunity for students to exercise their own imagination and increase their problem solving skills.

Engineering education has many software tools for demonstrating engineering concepts and serve as excellent teaching aides. These packages allow the instructor to demonstrate how the theory from lectures is applied in real-world applications. Using engineering software, an expert can demonstrate how to approach and solve complex problems. Traditional instructional methods limit the interaction between the instructor and the student. Basically, the instructor lectures and demonstrates a software package while the students observe and hopefully ask questions. This process is not very stimulating for the student and leads to poor retention of the material by the student.

The challenge of this project was the creation of an interactive teaching lab where students actively participate in the learning exercise. What happened to the trips to the blackboard by students? These exercises using the blackboard is an important learning exercise that reinforces concepts presented in a lecture format. Therefore, a teaching lab has been developed that utilizes a virtual blackboard. The virtual blackboard serves the same purpose as the physical blackboard in the classroom except the workspace is on the student's computer workstation.

Hardware. A new Electrical/Electronics Teaching Laboratory (EETL) was established with twelve (12) workstations and one teacher workstation (Figure 1). The student's computer was a Pentium III 700 MHz processor with 128 MB RAM running Windows NT 4.0. Each station had data acquisition capabilities through a 16 channel analog-to-digital converter (National Instruments, PCI-MIO-16E-4) and an input/output connector block (BNC-2120, National Instruments). The teacher workstation was a 750 MHz Pentium III with 128 MB RAM running Windows NT 4.0 Server with an 18 GB hard drive. This room had its own internal LAN running at 100 Mbps, and it was not connected to the World Wide Web.

The teacher's workstation provided the necessary tools for a multimedia presentation. The desktop screen on the teacher's station was projected onto the front screen through a connection to a computer projection system (MP7760, 3M Corp). When an instructor describes a physical device, the video input of the computer projection system is switched to the output of a CCD video camera (VK-C360N, Hitachi Corp). Now, all students can view the device during the explanation. The CCD video is mounted on a camera stand with lights.



Figure 1. Interactive teaching laboratory with 12 student workstations and teacher station.

An instructional objective in the electrical/electronic area is to provide more opportunities for hands-on active learning exercises. Introducing students to the operation of electronic instrumentation as well as virtual instrumentation helps achieve part of the objective. In addition to the virtual instrumentation (data acquisition), each workstation was equipped with a digital oscilloscope (Tektronix TDS 210), dual power supply (Agilent E3620A), digital multimeter (Fluke Model 45) and 2 MHz function generator (Leader LG 1301). To provide an ergonomic workstation, the instrumentation was mounted on shelves on each side of the monitor (Figure 2). This arrangement also met the guidelines for the American Disabilities Act.

Engineering Software. Software packages available for engineering design are readily available and very useful in strengthening lecture material. The basic software for report writing ('Microsoft Office Suite') and data analysis ('MatLab', 'TKSolver', 'StatMost') was installed on each workstation. In addition to the customary software, each workstation had specialized software for electrical engineering design:

- 'MultiSim 2001' (electrical/electronic simulation software) used in Circuit Analysis, Electronics, Sensors and Transducers, Motors and Power Distribution.
- 'LabVIEW 6i' (data acquisition and control) used in Sensors and Transducers.
- 'RSLinx', 'RSLogix500', 'RSLadder500' (programmable controller) used in Motors and Power Distribution.

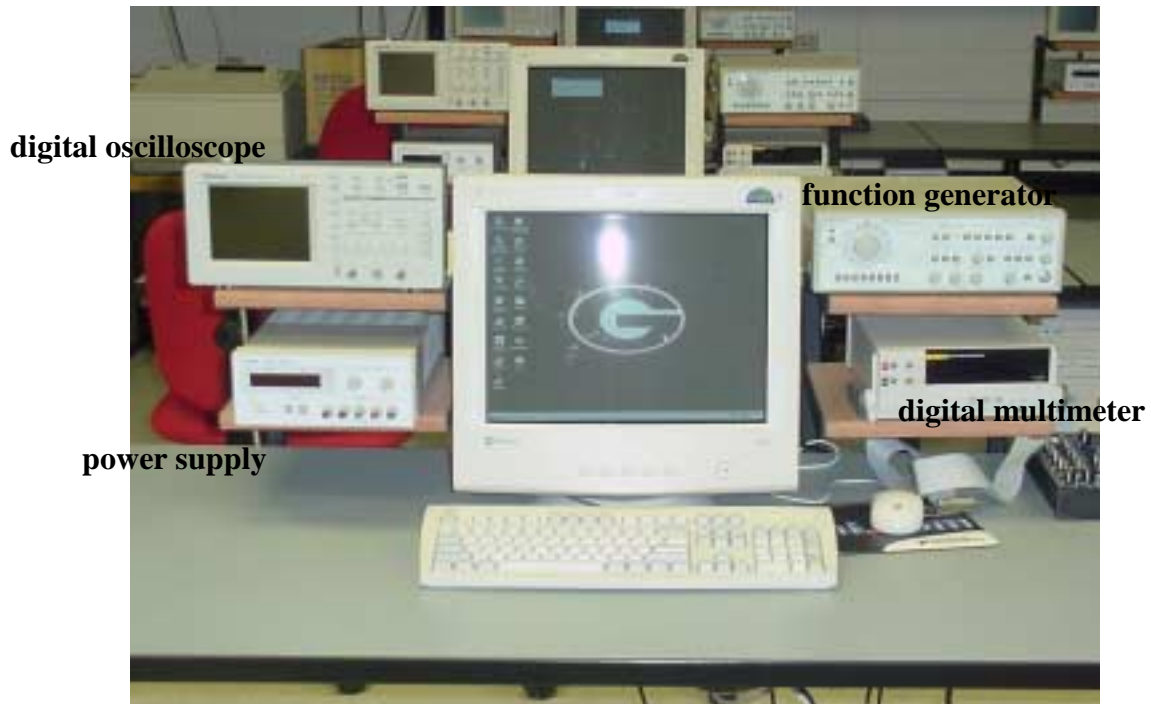


Figure 2. Electronic workstation containing the four basic electronic instruments and a computer data acquisition system.

Creating an Interactive Classroom. A unique feature of the new classroom was the ability of the instructor to actively interact with the students during an exercise (i.e. the creation of a virtual blackboard). Using features of 'NetMeeting' from Microsoft Corp., a classroom session was conducted where the instructor shared a single application ('MultiSim 2001') between three workstations. This arrangement created a virtual blackboard on each computer monitor where each student could contribute to the same project. A student participated in the class exercise by taking the control of the software package when requested without leaving his/her workstation. For example, one student was asked to select and place an integrated circuit in the workspace, while a second student inserted and connected a power supply. This process continued until the class completed the desired amplifier circuit. Although the concept was demonstrated with 'NetMeeting', it was difficult to setup the interactive session as well control the remote workstations.

A search for a software package that provided improved control of the workstations while maintaining the real-time interactive sessions identified 'Classrooms' v2.6 from DDES Corp. (www.DDES.com) as a solution. This software has two components: 1) Server that resides on the teacher station, and 2) Client that is installed on each student's workstation. 'Classrooms' works with Microsoft 'NetMeeting' v 2.1 for its application sharing, chatting and paint/storyboard features, while it has its own schemes for remote viewing and remote control of student PCs from the teacher station at the OS and application software levels. Optimum

performance is achieved in a 100 Mbps network environment. IP addresses must be static. The server (teacher station) recognizes individual workstations via one of three naming schemes: 1) Student log-in names (“pjones”), 2) PC names as identified from the local network domain (“PC82”), or 3) Specific name given to this particular PC during setup (“E-Station1”). This laboratory uses the PC names for identifying specific users connected to the server.

Types of Interactive Sessions. ‘Classrooms’ is particularly useful in teaching subject areas that have extensive software already developed for it and that its “knowledge and understanding” can be “built” from discrete blocks or modules. Through ‘Classrooms’, various formats of synchronous-collaborative” classes are conducted:

1. **Teacher-Led Demos.** Students can mimic the teacher actions on their own PCs (and thus can keep a record of their own personal work). The desktop from the instructor’s workstation (server) is displayed on the front screen, and the students perform the same operations as the instructor.
2. **Independent Study.** An instructor can directly intervene on a student workstation from the teacher station by viewing the remote workstation. This feature is useful during exercises when students work independently on an exercise (i.e. design an amplifier circuit) especially when a student reaches an impasse. The instructor can assist the student by sharing the student’s application. When sharing control (the student desktop is displayed on the instructor workstation), the teacher and the student actually are sharing simultaneously the student application with two sets of mouse and keyboard. Control of the application is transferred to whom-ever double-clicked and used the mouse previously. With our current computer configurations, the “visual feedbacks” of the teacher/student mouse and keyboard activities are practically instantaneously transmitted back to the teacher station and the student station. If the instructor elects to project the instructor desktop onto the front screen during the session, the instructor can use the opportunity as a problem solving exercise as the problem and solution is identified.
3. **Collaborative Learning.** A more interesting and truly asynchronous-collaborative learning mode is implemented by sharing a single application with the class. To setup a collaborative exercise, an application such as MultiSim 2001 or LabVIEW is launched on one of the student workstations. Next, the teacher switches to a mode where the single application is shared to all PCs in the lab (students & teacher alike). An application running on a single PC with 12 other keyboards, mouse and monitors connected to it has been established. Any PC can take control of the first student application and modify it using their keyboard and mouse. It might be necessary to combine this mode with the selective locking/unlocking feature to have an orderly teaching process. Once the first student starts the building process, the teacher can pass control to the next selected student to add the next construct to the total project, and so on until the project is completed. The final product becomes a collective effort and record of all student activities.

Example Session: Teaching Critical Thinking Skills. One of the best methods for teaching problem solving is through the mimicking of an expert.⁵ This individual is the instructor in the

classroom; therefore, an excellent opportunity exists to help students develop problem solving skills through the interaction with the instructor. In the EETL, designing, building and troubleshooting an electronic circuit is a prime candidate. Initially, the application MultiSim 2001 is shared with the class as described previously. The performance criteria for the amplifier circuit are defined (i.e. input and output voltage levels). Then, the design and construction phase begins on the virtual blackboard. The instructor requests a student to control the application by placing the cursor in the workspace and double-clicking the mouse button. After getting control, the student selects and places a component in the circuit. Another student will be requested to take control of the application and perform another operation. This process continues until the circuit has been completed. At this time, the instructor leads the class through a problem solving session by troubleshooting the circuit by asking questions (i.e. What instruments are needed to test the circuit?, Where and how should the instruments be connected?). The students must apply the ideas presented in lectures in order to answer the questions and perform the correct operation.

Additional Features. Control of the exchange of information within the classroom is important for a successful session. There are many features of ‘Classrooms’ that allow the instructor to control the exchange of information. There are many tools that have not been used. Below is a list of features used in the EETL:

View. Allows the teacher to remotely view a student PC. During a class, the teacher can view each PC desktop individually or a sequence display of a group. View does not allow remote control by the teacher.

Remote. Provides remote viewing and control by the teacher. During a remote session, the instructor can share the session with all or a select few of student PCs. Instructor can also initiate program execution on the student PC.

Locking/Unlocking. Allows the instructor to selectively lock-or-unlock some-or-all student PCs. To lock a student PC means that all mouse and keyboard activities on the student PC are disabled until the unlock signal is sent from the teacher station. This is a definite “attention-getter” tool.

Teachers Profiles. Each teacher can have his/her own password to get into the teaching system and his/her own profiles and folders for notes and quizzes.

Limitations. The speed of response can be slow when sharing some applications. This slow response is overcome by reminding students to be patient. When the students launch ‘Classrooms’ (connect to the ‘Classrooms’ server) at the same time, some of the workstations are unable to connect; therefore, the students must connect in groups of three. Some features do not operate as expected.

Expansion. In addition to the EETL, a General Computing Undergraduate Laboratory (GCUL) was established. This laboratory contains a teacher station (Pentium 4, 1.5 GHz, 384 MB RAM) on Windows 2000 Professional) serving 20 PCs (Pentium III @ 750 MHz and 128 MB RAM)

running on Windows NT 4.0 Workstation. Since students are assigned individual usernames for PCs in this lab, users are identified by their student login names in 'Classrooms'. 'Classrooms' has been used for teaching amplifier and signal conditioning, Java Programming and electrical circuits since the Spring 2001. In Fall 2001, we expanded its use to teaching courses in Discrete & Continuous Systems Modeling, Engineering Statistics and possibly Engineering Graphics. In Spring 2002, we'll further expand it into an Applied Vision class.

Some Thoughts for Improvement

The first goal of the 2nd author in teaching Java Programming is to improve on the problem-solving skills of the students, while teaching Java syntax is only a secondary goal. Presently, this Java class still needs to use a text editor to type up statements within the program. By Fall 2001 or Spring 2002, we hope to introduce UML (Unified Modeling Language) technology whereas one can concentrate on building a graphical structure of logical modules and algorithms while the UML "engine" itself can generate the actual and necessary Java code behind the graphical interface. This feature is actually already implemented by more "macro" modeling packages such as ARENA and STELLA for use in discrete and continuous systems modeling and LabWindows/CVI for data acquisition and control.

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BIOGRAPHICAL INFORMATION

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