The Mobile Electronics Studio at Rensselaer: Next Generation Engineering Education

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Abstract

The "Mobile Studio" project at Rensselaer is developing pedagogy and hardware/software that give students access to a full set of electronic instrumentation—the type found in Rensselaer labs and studios—through a small circuit board and their laptop computer, connected via USB. The system provides similar functionality to that of the laboratory equipment (scope, function generator, power supplies, DMM, etc.) currently associated with an instrumented studio classroom. Our goal is to further expand the studio pedagogy pioneered by Rensselaer to have students learn with technology in mobile environments that are no longer limited by network access and equipment issues. The development of the Mobile Studio has been taking place over several years and has been documented in a variety of forums. The present paper describes the implementation on a pilot basis in two courses in the School of Engineering at Rensselaer during the Spring 2006 term. Electric Circuits is the first course for Electrical Engineering and Computer and Systems Engineering, and Electronic Instrumentation is a service course for non-EE majors. The impacts on teaching and on student learning will be characterized. A brief description of expansion of the pilot courses in the Fall 2006 term will be described, along with our plans to extend this technology into other learning environments.

Background

Although they are extremely computer literate, today's engineering students frequently enter college without the same level of hands-on "tinkering" with hardware that prior generations exhibited. Gone are the days when students were ham radio operators, played with Erector sets and had tinkered extensively with electronic kits or simply taken things apart. As a result, students have less "gut intuition" than prior generations possessed when entering the job market.

Lab experimentation provides a sense of where things deviate from theory, offering the opportunity to explore non-ideal conditions; while also giving students the chance to play with hardware and gain the experience that helps them support their subsequent design courses. Hands-on, intellectually engaging studio course delivery was a revolutionary idea that has

improved the quality of education at Rensselaer over the past 12 years and has since been adopted, in various forms, by many other universities. Yet even with more engaging studio environments, student learning is still impeded by space constraints, insufficient time for laboratory activities (particularly to do the in-depth probing that leads to an intuitive feel for system design) and poorly designed equipment that takes up a great deal of space. Furthermore, the equipment sets can't be brought home for individual study, thus limiting the time for hands-on exploration that students need to grasp the "big ideas" in engineering.

Project Overview

Rensselaer, Howard, Rose-Hulman and UT-Dallas are developing and testing interactive multimedia modules and technologies as part of a NSF-CCLI sponsored project to aid the understanding of the "big ideas" in areas related to electrical engineering. Our aim is to develop and use educational technologies to eliminate the boundaries between theory provided in a lecture and practice; apply concepts in directed problem sessions; and enable/encourage our students' "hands-on" exploration of engineering principles, devices, and systems that have historically been restricted to specific laboratory facilities. The recently developed software and hardware (shown in the accompanying Figures 1-3) provides similar functionality to the laboratory equipment currently associated with a fully instrumented studio classroom. The Mobile Studio I/O board includes a dual trace 1 Ms/s oscilloscope, two function generators (FG), a multimeter and DC power supplies that can now be provided ***to each and every student***. With the advent of this personal laboratory, many hardware intensive course offerings can be held in normal classrooms rather than in specially equipped facilities. In addition, students can perform hands-on experiments outside of the classroom anywhere/ anytime (e.g. their dorm room), thus facilitating new opportunities for them to "tinker" and gain valuable insight through practical experience.

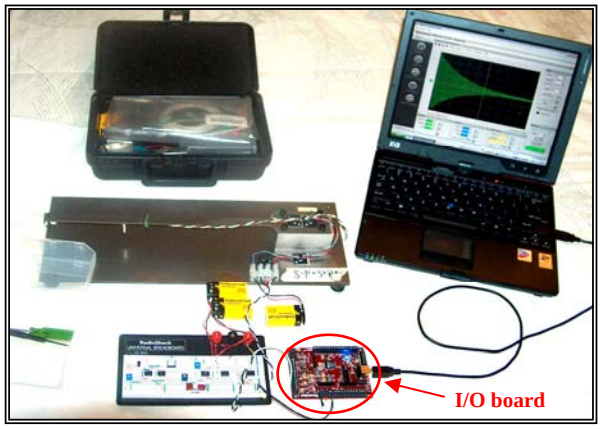

FIGURE 1 – Mobile Studio Laboratory I/O Board Setup

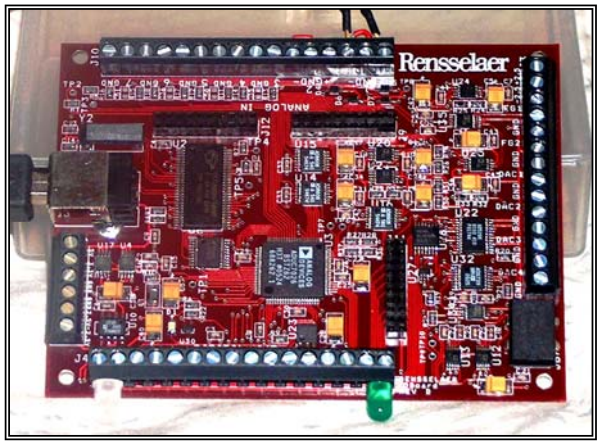

FIGURE 2 – Mobile Studio I/O Board

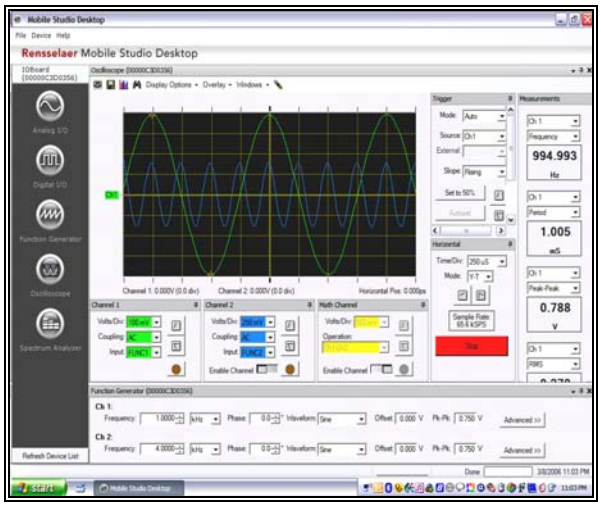

FIGURE 3 – I/O Board Software (Oscilloscope & FG)

Implementation

The project's developments are being piloted in five courses at Rensselaer and Howard University (a school that doesn't have dedicated studio facilities). Hardware oriented classrooms are now made possible with the Mobile Studio - for Howard's electrical engineering courses that used to be offered in lecture formats (e.g. Network Analysis – shown in Figure 4). For example, students are given a statement of the problem to be explored (Ohm's law, voltage division, Thevenin's theorem, etc.) or the quantities to be measured (voltage, current and resistance) and asked to both devise and conduct experiments and techniques to acquire the data using the I/O board and accompanying software (scope, DMM, & spectrum analyzer modules). They use interactive learning modules (Figure 5) and technologies in a manner where they are not fully guided through prescribed laboratory activities. In-class and take-home activities for Circuits and Electronics courses have been developed and piloted; where students design and perform experiments that illustrate the theory – in contrast to the educational sequence historically used to present concepts (e.g. theory – problem solving – experimentation). For example, students have been asked to design, develop and test a notch filter circuit to reduce 60Hz noise from an audio signal. The students create their circuits with the aid of Filters CAD and Pole/Zero modules (shown in Figure 5) along with the Mobile Studio hardware/software to then protoboard and evaluate their designs. The outcomes of the project's assessment and evaluation efforts to-date (which are directed by UAlbany's Evaluation Consortium) have shown an improvement in student performance that is directly coupled to the course's learning objectives.

The system was used as the sole instrumentation package during the spring 2006 semester in a course at Rensselaer entitled "Electronics Instrumentation" (ENGR-4300). This is a first course in circuits, signals, and instrumentation taken by NON-electrical and computer engineering students. It is required in the mechanical engineering program and serves as a multidisciplinary engineering elective in several others. The class was limited to 20 students because of the pilot nature of the experience, and it was taught by Prof. Millard (principal author of this paper). Although the classroom permitted wireless internet access, there were no special accommodations as a circuits laboratory. The mechanical engineering students traditionally

complain that this course is uninteresting and difficult, and they struggle with the material, even with our availability of studio electronics classrooms. However, the universal reception during this pilot version of EI was extremely positive. Students felt that they were more actively engaged in the learning process and that they developed a clearer understanding of concepts.

During the fall 2006 term, the pilot experience was expanded significantly. "Electronics Instrumentation" is being taught to a group of 59 (mostly) mechanical engineering students. At the same time, the protoboard is being used in the first electrical engineering course, "Electric Circuits" (ECSE-2100) to about 40 electrical engineering and computer and systems engineering majors. At the time of this writing, the courses were in progress, but early indications are that the system is working well for both groups and that we will see great advantages for our programs from this technology in the future.

Project developments have also been disseminated through a special museum program, traveling demo presentation and a 4th grade hands-on educational initiative; further providing teachers with STEM educational materials to utilize in/out of the classroom.

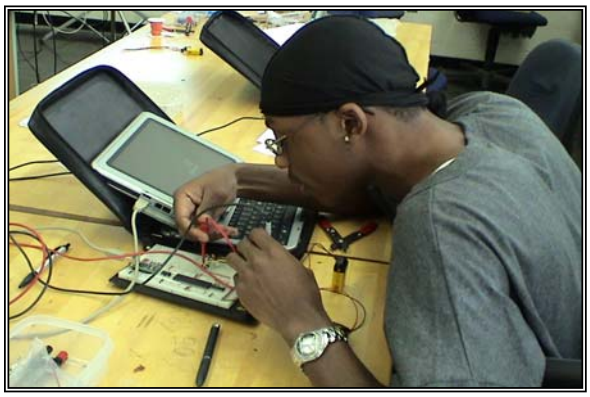

FIGURE 4 – Howard University Student Using the Mobile Studio to Develop a

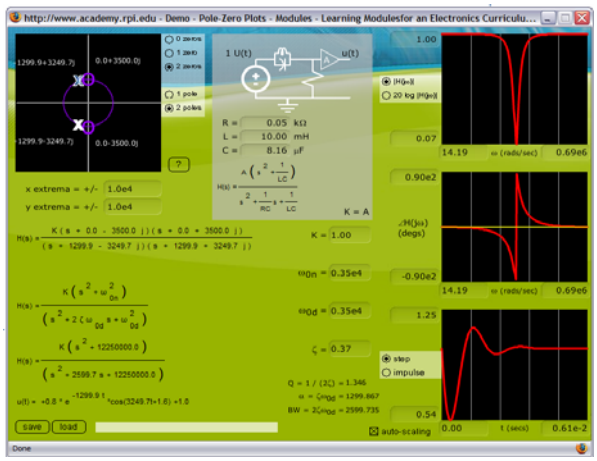

FIGURE 5 – Pole-Zero Learning Module (Used to Help Design and Understand the Operation of a 60Hz Audio Filter)

One Year from Now *(Cost/Deployment)*

We plan to infuse the technology and pedagogy into the large enrollment courses in engineering and science (e.g. Physics I&II) and expand the utilization of mobile studio classrooms campus/nation-wide. Ultimately, we will develop the Mobile Studio practices and the technology into a model that can be readily adopted by community colleges, universities, home-schooling providers, and K-12 institutions (building on the pilot activities currently underway) – to significantly impact student learning on a national scale. It is anticipated that the Mobile Studio hardware will be made readily available for others at an estimated cost of approximately $80/board; while the software is offered to interested parties via the Academy of Electronic Media website at: ***http://www.academy.rpi.edu***.

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