## The Pros and Cons of Remote Labs

"I hear...I forget; I see...I remember; I do...I understand." - Confucius, c. 500 BC

From Confucius to ABET 2000, from Beijing to Berlin and beyond, you'll find little dispute that laboratory exercises and experiments are an important adjunct to lectures when you're teaching engineering. Hands-on experience helps students understand the abstract concepts they hear and see in the classroom.

But just exactly how "hands-on" does a lab experience have to be? Can a student learn effectively using a remote lab, where actual test and measurement instruments can be controlled remotely via a local network or the Internet? What are the benefits and disadvantages of a remote lab? Will remote labs someday replace physical labs stocked with oscilloscopes, digital multimeters and teaching assistants?

We asked these questions of some of the visionary educators who have implemented remote labs at their universities. Everyone talked of the promise the technology holds. But the reviews were mixed when it came to evaluating the results of their remote lab experiences.

The Promise of Remote Labs Why have universities devoted scarce resources to developing remote labs? None of the remote lab implementers surveyed expected their remote labs to replace their traditional physical laboratories. They cited specific applications where remote labs add measurable benefit or they viewed it as a supplement or enhancement to



their traditional lab program. Remote lab benefits they mentioned include:

- Students can configure circuits and get results very quickly, which encourages them to do more "what if" exploring than they would in a physical lab.
- Students have the flexibility to log in and complete their assignments from any place in the world, and at any time they choose.
- Remote labs provide broader access to expensive and/or specialized equipment.
- A remote lab prepares students to work in "remote mode," a mode that some expect to become increasingly common in the workplace.
- Remote labs enable hands-on experiences for distance education.
  Professor David Naylor of the University of Illinois at Chicago is a remote lab enthusiast. His remote lab has been in use for about a year. Students – or anyone else who wants to – can access his remote lab via a web browser or a downloadable windows application.

By interfacing instrumentation with the computer, data can be automated. In this picture, taken at Carnegie Mellon, the computer system had to be more flexible since the circuit under analysis was unknown (CMU lab: The Black Box, accessible via www.EducatorsCorner.com/ links).

Once they're online, they can build their own circuits, select circuits from a menu or import pre-built circuits.

"When students are first starting out, it's easier to just use a pre-built circuit," said Naylor. "It enables them to get results with the click of a button. There's relatively little they can do wrong at that point. Then the next exercise is where they've actually got to build the circuit themselves. It's a case of confidence building."

"We use the remote lab here at the university as a supplement to our regular hands-on lab," said Naylor. "We have no intention of taking away the traditional labs. In terms of the kinds of hands-on skills that a practicing engineer needs, I think a hands-on lab is very important. I use this facility to bridge the gap between what we are doing in the classroom and the kinds of things that we do in our traditional lab."

## CMU ECE Remote Laboratory



Professor Yi Zheng from St. Cloud State University advocates remote labs for a very specific application: developing software for a digital signal processor board. "The development tool for digital signal processing is quite expensive," he said. "Most universities can not afford to buy workstations for all their students. Microprocessors for digital signal processing change dramatically and frequently. If you buy ten systems today, a year later they will be outdated and your money will be wasted. But if students need to learn these skills, we have to find a way to do it. This is one way to make it possible."

## The Reality

Carnegie Mellon University was one of the first engineering schools to use a remote lab for undergraduate students, beginning in the fall of 1995. Looking back at the school's remote lab history, Professor Daniel Stancil said, "Frankly, our experience at CMU has been mixed, although I continue to believe that remote experimentation is a powerful idea. I taught the remote course twice, each time drawing about ten students or less. This was suitable for experimenting, but was not a large enough level of interest to justify continued offerings. Rather than offering a specific dedicated course, we are now exploring ways that remote labs can be used to enhance existing courses in our curriculum."

Professor Zheng commented on the investment required to build and maintain a remote lab. "It is a big commitment in terms of both staff time and financial resources to develop and maintain a remote lab," he said. "If you don't have enough resources, it is very difficult." His school, St. Cloud University, spent close to \$300,000 over a two-year period developing and equipping four remote labs: a beginning circuits lab, an electronics lab, a communications lab and a DSP lab.

According to Zheng's colleague, Professor Michael Heneghan, the weak point of most remote labs is that students can't set up circuits themselves. "But for distance education, it's better than using simulation or watching someone else perform a lab on interactive TV," he said.

Was it worth the \$300,000 investment? "That remains to be seen," said Professor Heneghan, "but we are optimistic."

For more information on the remote labs at Carnegie Mellon University, St. Cloud State University and University of Illinois at Chicago, visit www.EducatorsCorner.com/links.

## Tips for Developing a Remote Lab

by Professor Daniel Stancil, Carnegie Mellon University

- The software must be reliable. Frequent software crashes frustrate students.
- You must have the ability to power cycle the instruments being controlled to recover from crashes.
- The remote lab must be a required part of the course, or offer clear added value to students. If they don't perceive a significant benefit, they won't use the remote lab.
- Experiments must be sufficiently flexible to allow students to explore a wide range of questions or conditions."Cookbook" labs with limited flexibility offer little attraction to bright students.