

## Laboratory Remote Operation: Features and Opportunities

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### Abstract

A number of laboratory experiments have been made available for remote operation via the Internet. These include some of the standard unit operations and controls systems laboratory stations. This paper looks at the features (or positive aspects or benefits or advantages) of these developments and the opportunities (or negative aspects or costs or disadvantages) of these developments. The paper presents and discusses both the student's viewpoints and the instructor's viewpoints.

### Remote Operation of Laboratory Experiments

Various experiments have been remotely at UTC since 1995. These are accessible on the Web at <http://chem.engr.utc.edu>. The scheme for this is shown in Figure 1. In most of the systems, the

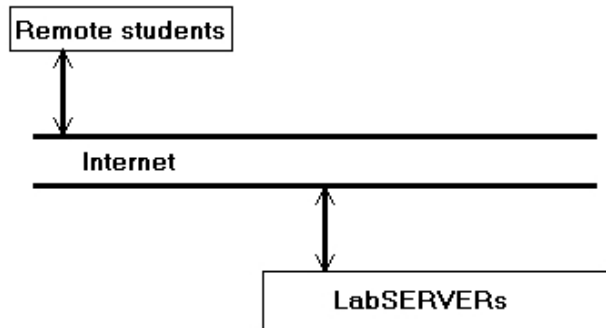


Figure 1. Diagram of internet connectivity to lab experiments

remote students user can access the experimental system with a conventional web browser. The Web site has "forms" that ask for parameters for the experiment to be run. When the user clicks on the "Run Experiment" button, the information is sent to the lab station via the internet. The lab station (on a first-come, first-served basis) runs the experiment and returns the results in graphical and tabular format to the user.

The lab stations are connected to the Internet and available for users 24 hours a day, 7 days a week. The stations available

include six stations for system dynamics and controls labs and five for unit operations labs.

### Experimental Setups

The system dynamics and controls experiments include a shell-and-tube heat exchanger, a pump and tank system, a motor-generator set, a blower and duct system and a pump and piping

system. The unit operations systems include a packed bed absorption unit, a distillation column, a set of packed bed porous-flow paths, a batch dryer, a pressure-swing-absorption unit and a Freon-cycle dehumidifier.

### On-Line Capabilities

For most of the systems, a wide variety of experiments can be designed by students and run remotely. The data and graphs that are generated in an experiment are saved on the Web server at UTC and can be retrieved by the student, a team member or instructor at any subsequent time.

### Features or Advantages

With 24x7 availability, students can have access to the lab at their convenience rather than at the convenience of the school or department. Students who need extra opportunities to absorb a concept can repeat an experiment as often as desire. Students working in teams can e-mail to each other the site reference for the results of an experiment for easier collaboration at distance.

### Opportunities or Disadvantages

This author believes that "hands-on" experiences are the most educational. Remotely run experiments are weak in this aspect. As facilities and technology expands, more live audio and visual can be added to give a greater sense of "being there."

### Features and Opportunities from the student's viewpoint

We have surveyed some of the students who have used the Web-capable laboratories. Their responses include those listed here:

- We can pick the time to meet to run the labs instead of being required to be here for a set class time
- The ability to perform experiments from remote locations
- You can run experiments during class time or at 3AM as well as turn in your reports at any time over the web
- I liked the freedom of the lab
- It worked out well being able to work at different times
- This was a new experience. Especially running the experiments on the Web, and sending the assignments by e-mail
- Web access learning is very important these days, when a lot of information is available and e-mail is taking the place of traditional phone calling and letter writing.

## Features and Opportunities from the instructor's viewpoint

This capability can be used in preparing and presenting "lectures," also. In a controls systems course, for example, I can bring in a variety of real, live data and graphs for any of the system identification or the feedback control experiments. Whether this is any more educational than data and graphs in a textbook is yet to be determined.

The ability to review a student's experimental results without scheduling a face-to-face meeting makes it much quicker sometimes to be able to give constructive advice about some facet of an experiment.

The development and maintenance time can be quite absorbing. All our remotely operated systems at UTC have been designed and built with in-house personnel. In future additions and replacements, we are going to out-source the construction, installation and demonstration of the systems.

## Conclusion

There are a number of aspects of remotely operated experiments in engineering labs that are quite valuable. There are opportunities for expanding and improving the technology.

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Dr. Henry is a professor in the area of chemical and environmental engineering at the University of Tennessee at Chattanooga. He received his Ph.D. from Princeton University. He has been teaching engineering for 27 years. He is interested in laboratory development for improved learning.