

Web-Operable Remote Experimentation in Lecture Courses

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Goals

- ▶ Long Term: Increase student exposure to experiment
 - ▶ Enhance conceptual understanding
 - ▶ Limited resources (TA and faculty time)
- ▶ Short Term: Test efficacy of remote experiments as a supplement to lectures.
 - ▶ Not a replacement of real laboratories
 - ▶ Technology is well developed. What is appropriate content?

Test Course: Material and Energy Balances. (Introduction to Chemical Engineering)

Abridged Course Objectives

1. Develop problem solving methodologies
2. Develop skills in teamwork and open-ended problem solving
3. Develop skills in technical-report writing and formal presentations
4. Provide computational experience with spreadsheets ...
5. Provide an introduction to Chemical Engineering as a profession.

Project Design Concepts

- ▶ Minimal class time devoted to experiment
 - ▶ well-designed user interface
 - ▶ eliminate networking problems
- ▶ Utilize well-supported software platform (Labview)
- ▶ Support concepts already being taught
- ▶ Right level of complexity
 - ▶ optimal number of variables for web-based experimentation?
 - ▶ encourage multiple visits.

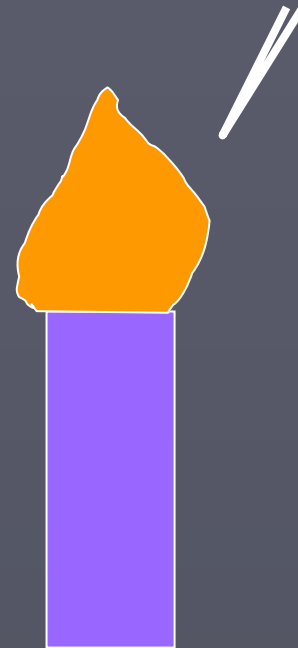
Test Vehicle: Adiabatic Flame Temperature Measurement

► User Controls:

- Thermocouple position
- Air/fuel ratio

► Open-Ended Assignment

- Groups of 3 or 4
- 10 percent of grade
- Two page written report (compare with calculations)



Screen Snapshots

X (mm) 12 **Y (mm)** 0

Fuel/Air Mole Ratio 0.070

Temperature (K) 300

Results

Fuel/Air Ratio	x-coord (mm)	y-coord (mm)	Temp (K)
0.070	0.000	0.000	300.152
0.070	12.000	0.000	300.152

Status Ready.

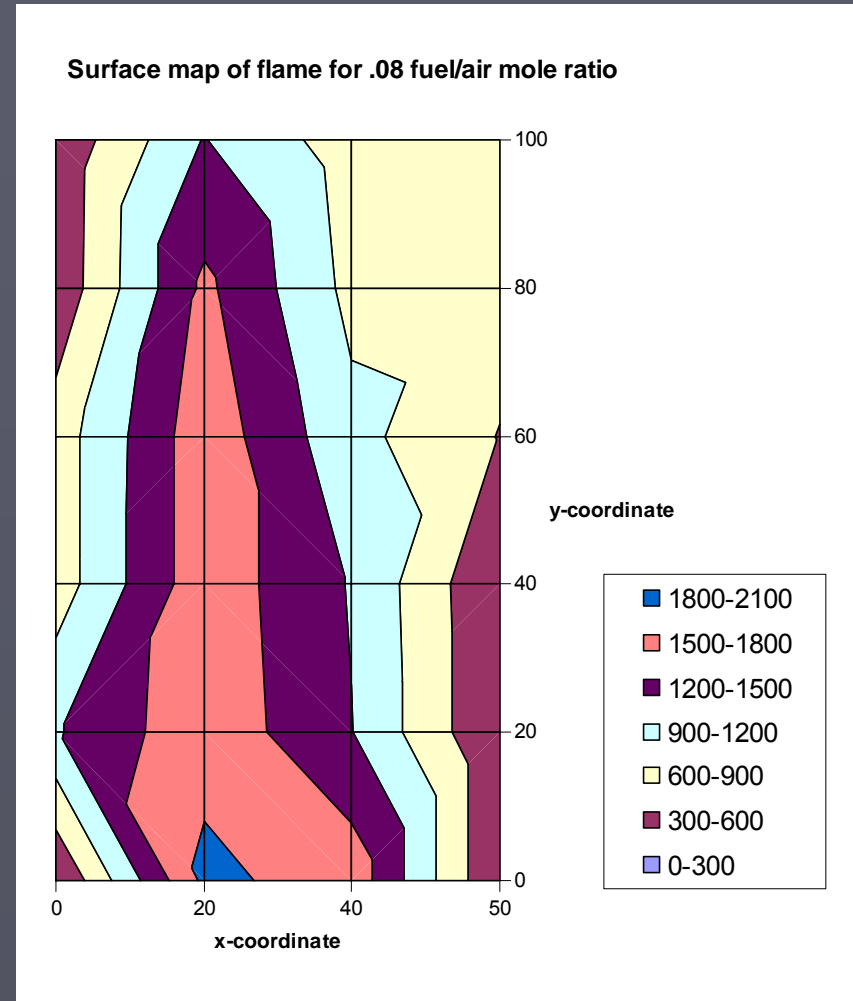
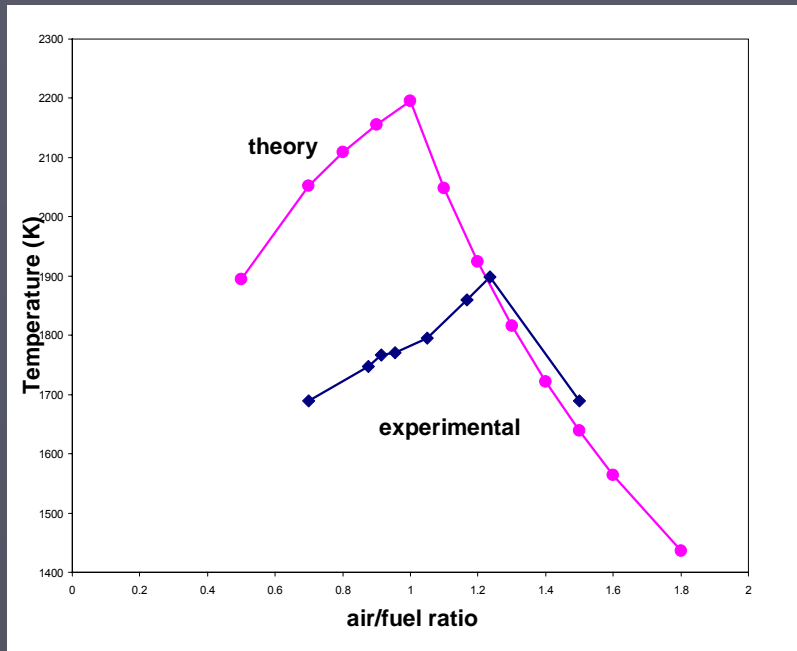
STOP LIGHT
HELP



Screen Snapshots



Student Results



Survey Results from 2002

1= strongly disagree
5= strongly agree

1. The remote experiment operation was easy to learn.

avg: 3.9

2. I would have had a better learning experience in a traditional hands-on laboratory.

avg: 2.8

3. I had difficulties downloading plug-ins and with connections to the server.

avg: 2.3

4. I prefer remote experiments to experiments in a traditional hands-on laboratory.

avg: 3.5

Survey Results (continued)

1= strongly disagree
5= strongly agree

5. Remote experiments can be as useful for providing a physical experience as hands-on experiments.

avg: 3.6

6. Remote experiments provide a better learning experience than a homework assignment on the subject.

avg: 3.8

7. The experiments would have been more effective as an individual instead of group assignment.

avg: 2.0

8. The ability to work at my desired time and pace is an important advantage of remote experiments.

avg: 4.4

Survey Results (continued)

9. How many times did you connect to the experiment to collect data? Do not count times that you connected to download files or to learn how to operate.

avg: 2 high: 6 low: 1

10. Did you use any data collected by other groups? Remember that you were allowed to!

yes: 10 no: 14

11. After taking initial data, did you plan and perform additional experiments?

yes: 17 no: 8

Results from 2003

- ▶ Survey has not yet been conducted
- ▶ Software has been improved in response to student suggestions
- ▶ Networking issues appeared
 - ▶ Long times for download of plug-in
 - ▶ Columbia University permissions
 - ▶ Students were dissatisfied – impacts learning.

Conclusions

- ▶ Remote experiments can be effectively used to reinforce lecture.
- ▶ 24/7 access to the experiment was highly valued by students
- ▶ Remote labs enable students to work at their preferred pace
- ▶ Remote labs enable adaptive design of experiment and open-ended assignments.

Acknowledgments

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