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The Laboratory World is Flat

Abstract

Labs operated at a distance via the Web allow for "multiple forms of collaboration—the sharing of knowledge and work—in real time, without regard to distance…." (Friedman, The World is Flat). This paper looks at Friedman's 10 "flatteners" and how they are or are not directly applicable to laboratories in engineering education.

This paper describes specific examples of collaboration of students and faculty over time and space that have occurred in the past 13 years in the use of remotely operated laboratories. The examples include engineering controls laboratory experiments and chemical and mechanical engineering laboratory experiments.

This developing capability enables sharing the use of expensive and/or unique laboratory equipment among multiple universities (e.g., combustion engine operation and performance, including environmental aspects, distillation columns, electric power switch systems). Alternatively, assignments can be made to compare the performance of two similar sets of equipment at different locations (e.g., heat exchangers, pumps, control systems). Students at two universities can collaborate over operation, data collection, data analysis and presentation of results.

Introduction

Thomas Friedman's book, The World is Flat, lists 10 phenomena that have contributed to what he calls the flattening of the world. He calls these "flatteners." This paper is an adaptation of the ideas in Friedman's book as they apply to laboratories for engineering education. A "flattened" world is one in which customers and merchants in Chattanooga, Chicago or Chile all have equal access to information and transactions. A "flattened" laboratory world is one in which students and faculty in Chattanooga, Chicago or Chile all have equal access to conducting laboratory experiments. Equal access means equal learning opportunities that are typical of quality laboratories throughout the academic world.

This paper looks at the opportunities and the challenges that are presented in the"flattened" laboratory world. The purpose of this paper is not to be an exhaustive review of all aspects of the flattened laboratory world; it is to present some common ideas in a different context to provoke discussion and development to aid engineering laboratory education.

The "Flatteners"

1. Personal computer's ability to communicate over phone lines. In the period 1969 – 1989, Atari, Commodore and Macintosh users with a modem could connect to the forerunners of AOL and Compuserve[1]. In 1990, with the introduction of Windows 3.0

for IBM-PCs or clones, the large base of users of these systems could transfer text, data and e-mail over phone-lines by a variety of services.

2. Early Web Browser. Mosaic, later named Netscape, was introduced in the early 1990's and Netscape (the company) went public in 1995. Netscape was free to individuals and schools and was low-cost to business users. It brought graphics, images, music and video to PCs over telephone lines. Netscape also allowed experiments and simulations to be viewed or controlled over the web in real time or near real-time.

One of the earliest applications of this real-time use of browsers was a camera that watched a coffee pot at Cambridge University[2]. Some of the earliest controlled experiments were introduced in 1994 at UC San Diego, in Australia, UTChattanooga and Carnegie-Mellon University. These allowed for remote students and faculty to design and run experiments and view the results either visually or graphically or with data observation.

3. Work-Flow Software. When various pieces of software can interchange data, commands and graphics, it became possible, for example, for a graph generated at a piece of equipment at some distance to be transmitted via the Web and dropped into a document (such as a report or presentation) by users at their own computers. At UTChattanooga, LabVIEW and Matlab programs have communicated with web servers, operated lab equipment on demand and returned data and graphs to the users at their browsers. For example, students using Simulink have remotely and directly controlled a heat-exchanger experiment from hundreds of miles away[3].

4. Open-Source Software. In software development, this is typified in the Linux operating system and the Apache web server. It allows for the collaboration of many smart (or not so smart, for that matter) people to develop useful and rich devices for users. A similar concept could facilitate the improvement and development of applications of web-based engineering experimentation. Jimbo Wales, the founder of Wikipedia believes that everyone should have free access to all human knowledge. With further development it will give every student with a computer and a Web connection the access to a slate of quality experiment throughout the world.

5. Outsourcing. Let someone else make something or do something for me that they do well and cheaper. In the paradigm of Web-based labs, all universities don't need to have all experimental stations that contribute to engineering education. All universities don't have to build the building facilities, design and build or purchase the equipment, receive and install and maintain the equipment. For example, one school could have a batch distillation column and another have a continuous distillation system; with Web-based sharing, students at both schools could learn about 2 distinct ways of distillation.

6. Offshoring. Friedman uses a metaphor of running with gazelles and eating with lions. In engineering education parlance, this can apply to our students being able to run experiments with the best equipment and systems available and to get the "meat" of the lessons along with the students at the strongest schools that have their labs available online.

7. Supply-chaining. See 8, below.

8. Insourcing. As interesting as these are to economists and the author Friedman, their connection with Web-based laboratory experimentation is tenuous.

9. In-Forming. Similar to the ideas around #4. Open-Source Software, this flattener comes about because all people have access to the same information. With some Web-based experimentation systems, multiple users can simultaneously observe an experiment in progress. If these users are members of a learning team or student and instructor, they can communicate (again via the web or any other way) about the design and progress of the experiment.

10. “Steroids.” Friedman talks about the plethora of advances in technology that surround us now: digital, personal, mobile and virtual. “Your desk goes with you wherever you are,” quotes Friedman of Alan Cohen, a wireless communication guru[4]. In laboratory language, it is safe to say that your lab is with you wherever you have your computer and Internet connection.

Implications and Conclusion

Friedman goes on to talk about the “Triple Convergence.” Jim Pinto[5] describes these [with amendments for laboratory applications] as

1. The creation of a global, web-enabled playing field that allows multiple forms of collaboration, the sharing of [equipment,] knowledge and work, without regard to distance or geography, and soon even language.
2. Global [laboratories] lose walls, floors and buildings. [Students and faculty now have] a vast, global pool of [instructors and technicians], assembled (and disassembled) according to needs.
3. New opportunities are created for individuals to [cooperate with] anyone, anywhere in the world using the new, "flat" rules.

These are exciting times with opportunities for improving the access to equipment for students and faculty throughout the colleges and universities in the US as well as around the world.

Bibliography and other References cited

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4. The World is Flat, Thomas Friedman, first ed., 2005, page 168.

5. http://www.jimpinto.com/writings/flatworld.html accessed 17 January 2007.