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Web-based Laboratories: How Does That Affect Pedagogy? Thoughts for a Panel Discussion

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***Abstract* — The author presents a few questions for discussion at the Panel on web-based laboratories. The key issue is whether and how such laboratories can enhance the pedagogy. Is this only a technological trend or are there real values in creating online labs for real-time systems education? Answers to sample questions from the literature are reviewed.**

I. Introduction

WEB-BASED or online laboratories are a very hot issue in contemporary education in all engineering and science disciplines. They are considered to be the technology alternative and complementary to traditionally organized hands-on labs, where students have direct physical contact with equipment to conduct experiments, as well as to simulation labs, where experiments are modeled using computer software and access is provided either directly in the lab or virtually via the Internet.

While web-based labs are a very attractive option to pursue, especially in cases with expensive lab equipment, when only a few institutions can afford it, or in cases when non-traditional students have difficulties meeting the time frame the labs are offered, there are still several issues related to pedagogy, whether lab experiments conducted via the web have intrinsic value and provide the level of education and experiences comparable with traditionally conducted labs. These issues are of concern to faculty teaching courses with such labs as well as to the institutions hosting these labs, since the investment of time and resources in creating and maintaining web-based labs is significant and needs to be justified in a longer term.

The objective of this panel session is to review some of the existing approaches to offering web-based laboratories and discuss issues affecting the pedagogy of such labs. The discussion is based on the most recent publications on web-based labs reviewed by the panel proponent. A summary of the issues related to pedagogy raised in some of these publications is presented below.

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II. Questions Related to Pedagogy

Serious publications on web-based laboratories began to appear in the early 2000's [1]-[3]. They represented an overall trend in transitioning to intercontinental learning [4]-[5] and concerned a variety of disciplines, from sciences [6] to engineering [7]-[9]. More recently, a proliferation of papers on remote, web-based labs is observed. They report on developments not only in disciplines traditionally considered the most advanced in remote experimentation, such as control engineering and robotics [10]-[12], but also in electronics, in courses using FPGA's [13] and PLC's [14], optical circuits [15] and antennas [16], as well as in physics [17], chemical engineering [18], materials research [19] and energy research [20]. Some authors propose generic labs [21], as well as try to analyze the phenomenon in comparison to hands-on and simulation labs [22]. No major work however, to the author's knowledge, has been done in bringing computer science or software engineering labs to the web.

A. Four Basic Questions

In this view, the author believes that some basic questions need to be asked, first, regarding the existence or necessity of building such labs. Assuming the basic architecture of a web-based lab, as illustrated in Fig. 1, the following four questions come to mind:

Q1) What is the place of a web-based lab in a Computer Science or a Software Engineering program or a course?

Q2) Once the lab is in place, for conducting computer science or software engineering experiments in a web based lab: is there an ideal model?

Q3) Developing software for remote equipment: how does a web-based lab help?

Q4) Is there really an intellectual value added to a course with remote web-based laboratories?

My understanding of these four questions is as follows: Q1 is setting the stage for the discussion, formulates the requirements for a lab, Q2 and Q3 are meant to discuss the practice of remote labs, and Q4 is meant to stimulate the participants to derive some conclusions.

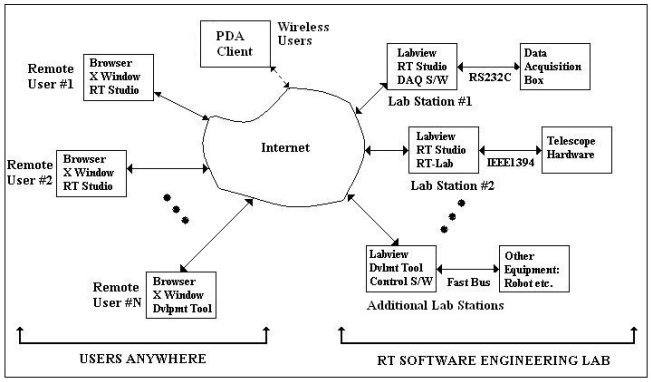

Fig. 1 System architecture of a typical web-based lab.

B. Addressing the Pedagogy

Educators who have already implemented web-based labs often present their views on educational values of such labs and the challenges they are facing. Ma and Nickerson [22] review a number of early decade publications on web-based labs and mention several advantages such labs might bring to the table:

- sharing expensive experimental devices with a pool of schools
- increasing the availability of devices over time and their accessibility from different locations
- increasing the number of students that have lab access
- increasing student motivation and interest in conducting experiments.

Schools that started building and offering online labs first, offer a number of interesting observations what such labs can bring to pedagogy [21]:

- web labs enhanced conceptual learning, stimulated higher-order thinking, and reinforced individual styles of learning in multiple ways
- web labs allowed students to control their own learning process, while enabling faculty to maintain factual rigor and coherence throughout the course.

Among the challenges, ones the most frequently listed include: providing extended technical support, merit-based assistance to students in extended hours, and practical cost to maintain such labs.

III. Summary and Conclusion

Being an important new lab component of any course, in addition to hands-on and simulation labs, web-based labs are still facing multiple challenges. It is an open question whether they increase an educational value of a course. It is also unclear whether they have a chance one day to replace traditional labs, filled with instrumentation and operated like a shop. One thing remains certain, however, as the world of technology clearly moves towards operating devices remotely, student experience with remote control of equipment will become invaluable on the job. It is hoped that some of the questions asked in this note will be answered in the discussion.

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