AAEE 2007 Workshop on Remote Laboratories: Sharing Expertise, Sharing Resources

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***Abstract* – Laboratories are an integral element of Engineering courses within Australia. The Engineers Australia accreditation criteria includes *"proficiency in appropriate laboratory procedures; the use of test rigs, instrumentation and test equipment;"* as well as *"Access to simulation, visualisation, analysis, design, documentation, planning, communication and management tools as well as test and measurement equipment and information resources appropriate to current industry practice"*. Laboratory infrastructure is, however, expensive to maintain and imposes significant logistical constraints on course delivery. One option to reduce these burdens is the use of remote laboratories – where students are able to remotely interact with the laboratory hardware. Remote laboratories are an increasingly popular innovation in engineering education, but their development has for the large part been an ad hoc process - they are developed in isolation to address the needs of a particular laboratory class; and they are often regarded as a "second-best" substitute for the real thing. This workshop is aimed at sharing experiences within the Australian Engineering education environment, with the goal of ultimately developing a remote laboratories special interest group and/or consortium tasked with the ongoing development and sharing of remote laboratory facilities.**

Index Terms – Laboratories, Engineering, Education, Pedagogy, Remote

INTRODUCTION

Laboratory classes are widely accepted as a crucial part of an undergraduate engineering degree. The Engineers Australia accreditation criteria for Engineering courses includes several elements directly related to laboratories. For example: "*proficiency in appropriate laboratory procedures; the use of test rigs, instrumentation and test equipment*"; and "*Access to simulation, visualisation, analysis, design, documentation, planning, communication and management tools as well as test and measurement equipment and information resources appropriate to current industry practice*".

Development and maintenance of laboratory infrastructure is, however, a significant challenge for Faculties of Engineering. Whilst the infrastructure is certainly important to the educational processes, it is often expensive to develop, particularly given its sporadic usage and the limited available resources. The physical nature of the laboratories also imposes significant logistical constraints on course delivery. The traditional, proximal, model of the laboratory class is also coming under increasing pressure because of the changing demands of engineering courses. Scheduling increasingly large numbers of small groups of students, each of which requires an hour (or more) of continuous and adequately supervised access to an expensive piece of laboratory equipment, is a difficult and expensive task.

One option to assist in reducing these burdens is the use of either virtual (i.e. simulations) or remote laboratories. In this latter case students are able to remotely interact with the actual physical laboratory hardware. Web-based remote laboratories are an increasingly popular innovation in engineering education, having first been developed in the mid-1990's. Their development however has for the large part been an ad hoc process - they are developed in isolation to address the needs of a particular laboratory class; and they are often regarded as a "second-best" substitute for the real thing.

The most significant benefits of remote laboratories will be realised when there is substantial sharing of both expertise and resources. This workshop is aimed at actively addressing the first of these, and beginning the process of the second – i.e. it will be an opportunity to share experiences with regard to the development and utilisation of remote laboratories (particularly with regard to the pedagogic design of remote laboratory experiences). The workshop will also have as a key objective the establishment of a special interest group tasked with exploring avenues for the joint development and sharing of remote laboratory infrastructure within Australia.

ISSUES TO BE CONSIDERED

Whilst the initial motivations for remote laboratories were logistical, more recently the educational impact is being increasingly seriously considered. Research reported in the engineering education literature has been ambiguous in terms of the differences in the educational outcomes achieved by remote laboratories versus proximal laboratories, as well as students' perceptions of the experience.

Within the above context, the workshop will invite sharing of experiences, particularly where they provide insight into any of the following issues and questions:

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- What benefits are to be gained from the use of remote laboratories?
- How does the use of remote laboratories affect learning when compared to proximal laboratories?
- What types of laboratory experiences are best suited to a remote access model?
- What pedagogic design considerations must be taken into account when developing remote laboratories?
- How best can cross-institutional sharing of laboratory infrastructure be facilitated?
- Is there interest in establishing a SIG in remote laboratories?
- What technical infrastructure needs to be in place to facilitate development and sharing of remote laboratories?
- Is there merit in developing a common platform?
- What organisational, social, political issues will need to be overcome in order to achieve effective sharing?

WORKSHOP FORMAT

The facilitators for this workshop are all strong believers in active/cooperative learning. As such, the workshop will be delivered in an active/collaborative format. Rather than inviting conventional academic paper submissions, the workshop will invite expressions of interest in attending the workshop. The number of places will be restricted, and if the number of applications exceeds the number of places, then preference will be given to achieving an effective balance across the sector.

Those who are selected to attend will all be requested to provide (two weeks before the workshop) a brief position statement (maximum of 2 pages) outlining the following items:

- The current status of the development of remote laboratories at the attendee's home institution.
- A brief position on 4 or more of the above issues.

A failure to provide the statement will result in withdrawal of the offer of attendance and the position being offered to another applicant.

At the workshop, the participants will be asked to each provide an initial overview of their position. The workshop will then split into subgroups tasked with identifying key questions in the development of a widespread remote laboratory collaboration within Australian Universities.

Throughout the workshop specific examples of remote laboratory equipment throughout the world will be accessed to enable key points to be illustrated in the discussion.

THE DELIVERABLES

The workshop aims to achieve the following outcomes:

- A stronger community of practice amongst participants.
- A full list of current remote laboratory activities within Australia, and the status of the various projects.
- The formation of an Australian special interest group, and a clear agenda for this group with regard to the ongoing development of remote laboratories (if there is strong interest in the formation of such a group).
- A draft outline of a 12 month plan for the ongoing development / activities of the SIG

RELEVANT LITERATURE

[1] Feisel, L. D. and Rosa, A. J., "The Role of the Laboratory in Undergraduate Engineering Education," Journal of Engineering Education, vol. 94, pp. 121-130, 2005.

[2] Scanlon, E., Morris, E., Di Paolo, T., and Cooper, M., "Contemporary approaches to learning science: Technology-mediated practical work," Studies in Science Education, vol. 38, pp. 73-112, 2002.

[3] Antsaklis, P., Basar, T., deCarlo, R., McClamroch, N. H., Spong, M. W., and Yurkovich, S., "Report on the NSF/CSS Workshop on New Directions in Control Engineering Education," IEEE Control Systems, vol. 19, pp. 53-58, 1999.

[4] Aktan, B., Bohus, C. A., Crowl, L. A., and Shor, M. H., "Distance Learning Applied to Control Engineering Laboratories," IEEE Transactions on Education, vol. 39, pp. 320-326, 1996.

[5] Trevelyan, J., "Experience with Remote Laboratories in Engineering Education," presented at 14th Ann Conf Aust. Assoc. Eng. Educ, Melbourne, Australia, 2003.

[6] Ma, J. and Nickerson, J. V., "Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review," ACM Computing Surveys, vol. 38, 2006.

[7] Imbrie, P. K. and Raghavan, S., "Work In Progress - A Remote e-Laboratory for Student Investigation, Manipulation and Learning," presented at 35th ASEE/IEEE Frontiers in Education Conference, Indianapolis, IN, 2005.

[8] Ogot, M., Elliot, G., and Glumac, N., "An Assessment of In-Person and Remotely Operated Laboratories," Journal of Engineering Education, vol. 92, pp. 57-64, 2003.

[9] Lindsay, E. D. and Good, M. C., "Effects of Laboratory Access Modes Upon Learning Outcomes," IEEE Transactions on Education, vol. 48, pp. 619-631, 2005.

[10] Lindsay, E. D. and Good, M. C., "Effects of Access Modes Upon Students' Perceptions of Learning Objectives and Outcomes," presented at 15th Annual Conference for the Australasian Association for Engineering Education, Toowoomba, Australia,, 2004.