TEACHING TECHNIQUES FOR USING REMOTE LABORATORIES

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Table of Contents

1   Introduction

Ideally, having students obtain exposure to laboratory learning with remote laboratories should be no different to that with conventional hands-on laboratory environments.   However, there are some slightly different approaches which can be taken to streamline the learning exercises for the students.

The purpose of this document is to ensure that both students and teaching staff are conversant with the most appropriate ways to employ remote laboratory learning exercises in coursework.

It's possible to identify several phases from exploration through to usage which an academic might complete, when considering the use of remote laboratories in undergraduate coursework programmes – Discovery, Planning, Pedagogy, Development, Student Induction and Usage.

2   Discovery

Essentially learning what remote laboratories are already in existence and available for use. Sample lessons can be downloaded and evaluated, along with information and specifications relating to the apparatus hardware and capabilities.   The sample lessons can be completed by the academic to assess fitness for purpose – some possible variations could be earmarked at this time such that the learning exercise be better tailored to meet a specific requirement.

3   Planning

If a decision is made to test or trial the usage of a TLI-managed remote laboratory by integrating it into a course/unit/subject, certain technical prerequisites must be attended to – for example university firewall/proxy (RDP, video) policies, PC laboratory firewall and desktop permissions in student laboratories (RDP, java applet execution) and the installation of web-browser video plugins (WMP, VLC).   These are not onerous undertakings in the main, but do require the assistance and acquiescence of IT support staff at the academic's institution.

Once these preliminaries are completed and tested, the academic prepares a lesson (by adapting TLI-supplied or writing their own). Of course, the lesson does not need to be centred on remote laboratory use only – it can incorporate both theoretical (i.e. offline calculations and other forms of pre-work) and practical (i.e. online use of remote laboratory) activities.   With this accomplished the academic has developed a familiarity with and confidence in using the remote laboratory.

At this point it is appropriate to introduce tutors and any other teaching support staff to the remote laboratory and to ensure they are competent in using it and assisting students.

The next step is to determine a timeline for usage of the remote laboratory which fits within the planned weekly schedule for the subject.   To this end the academic defines reasonable access period (2-4 weeks per lesson, depending on complexity) and makes a booking for the use of the remote laboratory through TLI.   To accommodate large classes, it might make sense to consider splitting them up into separate periods/groups

(again, usage can be negotiated with TLI).   The last step would be to specify the assignment due-date and consider late submissions – in precisely the same way as would be done for any other laboratory learning exercise.

4   Pedagogy

The teaching and learning aspects of remote laboratory usage have been the focus of a vibrant international research community for over a decade.   The TLI website contains detailed publications which features much of the research, in various forms.   It is recommended that an academic considering the use of remote laboratories for the first time, peruse the body of work in order to satisfy themselves that this particular laboratory access mode does deliver on many learning outcomes very effectively.

5   Student Induction

The student users should next be introduced to the concept of remotely accessible laboratory hardware and apparatus – what a remote laboratory actually is (real hardware, live interaction, available 24/7 from anywhere, simultaneous access and limitations on sharing, and support availability).   Fortunately, most contemporary students already have extensive familiarity with the Internet and assisting them to appreciate the use of a remote laboratory is not as onerous as it once was.

A technique which is known to work well is to demonstrate to the students in-class how to access the remote laboratory, and to interact with the apparatus and equipment before proceeding to the lesson content and the learning exercise.   The students can be encouraged to plan ahead and use the booking feature.   Standard techniques of good practice still apply – pointing out the consequences of leaving everything to the last minute and the possibility of having to endure a long time queuing to access the equipment.   Lastly, it's necessary to point out that helpdesk availability for all login and technical issues can be delivered, and that lesson/assignment questions will naturally be handled by academic, not by TLI.

6   Usage

Once the students set about commencing use of the remote laboratory, operational matters of support and guidance become the logical focus.   Requesting assistance from TLI on matters relating to technical and administrative issues is suggested.   Access periods are managed by TLI, so requesting the use of a remote laboratory for a period of time (for example between the second and fifth weeks of a particular semester) and extending or modifying this interval are matters which TLI can directly assist with.   TLI can also providing reporting information, for example usage logs – which aids with the efficient usage of the resources and provides an audit capability.

7   Coordination/Administration

TLI is ready to assist with requests for trial usage and to direct an academic enquiry to resources contained

within the TLI website that are of value to teaching staff whom are new to the concept of remote laboratories. Applications for specific usage periods or intervals are also accommodated by TLI.

8   Open questions

There are still of course, some questions which have no readily universal answer.   This reflects the individual nature of many laboratory learning exercises and scenarios and whereas the questions are not all intractable in nature, they often require the development of an individually appropriate solution.   Examples are:

1. How to encourage students to use laboratories early rather than late in the allotted time for their completion?   A time-honoured problem, which is not restricted to remote laboratories per se. Many teaching academics have developed their own strategies for this, which often include staged submissions in the form of deliverable milestones.
2. How to exploit unique remote laboratory features (such as repeated access) in lessons for the benefit of learning outcomes?   Remote laboratories don't have an occupational health and safety requirement for supervising staff to be in attendance.   This means that uncharacteristically, students are permitted (even encouraged) to re-do parts of laboratory exercises to confirm or refute result sets which might have been collected some time prior.   This is a paradigm shift from the scenario whereby students are permitted actual hands-on access in a conventional laboratory for just a limited time-slot and their opportunity to complete the work can be rushed, disorganised and fleeting, not the circumstances best suited to deeper reflective learning.
3. How to encourage students to book sessions well ahead of time and then use them?   Again, a methodical work practice is valuable but often not seen as necessary by student learners … until it's too late!

A usage scenario

Let's commence with a scenario which exemplifies suitable usage practice …

Louise, a lecturer at some university becomes aware of the TLI network and checks the TLI website to see what types of laboratory apparatus types (or "rigs") are available for use.   A list is currently held at, http://www.labshare.edu.au/catalogue/rigtype.   In any case, Louise discovers that there are some Coupled Tanks Apparatus sets which can be used for lessons in PID control – she thinks that she might be able to make use of these for the course in automatic control she teaches at her university.

The first things Louise wants to know are how do the rigs work and what can they be made to do?

These questions can be answered by content contained within the TLI online Catalogue which is a collection of

rigs hosted on the TLI website, specifically directed at assisting academics using the remote laboratories. Among the many resources there are sample laboratory experiments which give can serve as immediately useful exercises ready to offer students (they are in fact, real documents used in the past), or they can be treated as starting points for Louise to develop her own laboratory experiments for her students.   There are also some more general publications which reinforce the pedagogical aspects of remote laboratories in the contemporary curriculum, but for the moment...

Louise downloads the sample experiments and reads over them, noting points that she thinks she might incorporate directly and other things she might change for her own purposes.

Louise obtains an account and logs in to use one of the Coupled Tanks rigs to test out the way in which the rig works and the interaction offered by the remote laboratory interface.   As an accomplished specialist in her field of automatic control, Louise already understands the classical problem of two coupled tanks and is intimately familiar with the derivation of the non-linear mathematical models of the plants, the design of various types of controllers and their simulation and evaluation using a tool like MATLAB.   In fact, in the past she has used coupled tanks problem as an example control problem in her tutorials, but not actually had access to model plants with which to get her students to apply their controller designs to real hardware – this offers her a new opportunity to improve her students understanding.

Louise works through the sample laboratory exercise and satisfies herself that the rig works in the way it should and that the remote labs system provides her with a secure and robust connection to the rig.   She is able to work through the laboratory experiment in the same way that she would do so if the rig was available in one of her own on-campus laboratories.

Louise is ready to invest a little time in developing her own experiment procedure, using the sample from the Resource Kit as a starting point.   In a couple of hours, this is complete and she is ready to set dates for its issue to her students and when they should complete it and produce a report for her to assess.   This brings about the next step … Louse needs to tell her tutors and students how the remote laboratory works.

There are two modes in which Louise's students can access the coupled tanks rigs.   They can log in to the system and select one of the rigs if one or more is free, or they can join a queue if all the rigs are in use – this directly mimics the way in which conventional hands-on laboratories work.   There are rarely enough sets of apparatus to go around, the students either work in groups (which present its own ups and downs) or they queue, waiting for rigs to become free as other students finish their work.   The alternative mode is a pre-determined booking system – using the UTS remote labs reservation system, the student selects from a list of free timeslots, one which is suitable to them and the rig will be reserved for them to log in and use (as long as

they're prompt, otherwise their booking is cancelled and their rig is returned to the pool for the queuing students). This is all a little cumbersome to explain, so Louise elects to demonstrate it all working in the lecture in which she releases the laboratory exercise to the students.

> *Louise makes a booking (as above) for a timeslot which corresponds to her lecture time. She ensures her tutors will also be present and then during the lecture she demonstrates logging in, manipulating and controlling the rig, gathering results from the user interface and logging off with the results ready for inclusion in a report. Finally, Louise explains to the students that there is a finite number of the coupled tanks rigs and that the whole class won't be able to log in and use them at the same time – there aren't enough. This is why she does the demonstration herself – perhaps in a lecture theatre with internet access and a data projector. She allows the students a couple of weeks to complete the experiment and submit a report and publishes a submission date for the report.*

This completes the preparation and delivery aspects of the exercise as far as Louise is concerned – her students can now conduct an experiment that they wouldn't have otherwise had access to: They can do the pre-work in their own time, they then either take their chances and queue for a rig or they make a booking, they carry out the experiment, complete a report and submit it in the conventional way – perhaps printing it out and submitting it in person, or perhaps using an LMS at Louise's university to submit an electronic document.

9   What to do and what not to do

Louise's preparation should ensure a successful learning experience for her students – the things she did properly were …

- She familiarised herself with TLI and what it offers and what it can't offer by looking over the TLI website
- She downloaded the sample experiment and worked through it, using the rig in the role of a student, but with the presence of mind and experience of a teacher
- She decided upon her own variations and produced her own experiment specification which she knew could be completed by the students on the apparatus available, and she knew how long it would take
- She made a booking to guarantee herself access to the rig and completed a demonstration to her students and her teaching support staff
- She showed the rig in operation and gave the students confidence that the experiment would be workable and that it would deliver to them an opportunity to complete the learning exercise from home or elsewhere

The things Louise didn't do were …

- Cut corners on preparation, or delegate it without ensuring that it was being done properly
- Make assumptions about the way in which this aspect of distance-mode learning needs to be implemented

10 What TLI can do and what it can't …

10.1 TLI can …

- deal with enquiries from academics about the usage and availability of rigs
- offer sample experiment and suggestions on rig usage
- provide support on the development of rigs which can be hosted at various universities and help integrate them into the TLI network
- provide resources which include publications dealing with the pedagogical implications of remote laboratory usage

10.2 TLI can't …

- respond to enquiries from students about experiments (this is the responsibility the teaching academic at the institution the student belongs to, as usual)
- disclose information relating to individual students which might contravene privacy laws