Discussion Paper
on
Remote & Web-based
Science Labs

for BCcampus Articulation and Transfer of Remote and
Web-based Science Lab Curriculum Project

by Penny Le Couteur
June 2009

This research is funded by BCcampus
CC BY-NC-ND
This paper is licensed under the Creative Commons licence.
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>3</td>
</tr>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>Definitions</td>
<td>5</td>
</tr>
<tr>
<td>Perspective on remote and web-based labs</td>
<td>6</td>
</tr>
<tr>
<td>Learning objectives for science labs</td>
<td>7</td>
</tr>
<tr>
<td>Issues - and possible solutions</td>
<td>9</td>
</tr>
<tr>
<td>#1 Academic integrity</td>
<td>9</td>
</tr>
<tr>
<td>#2 Skills development</td>
<td>11</td>
</tr>
<tr>
<td>#3 Cost</td>
<td>13</td>
</tr>
<tr>
<td>#4 Transfer issues</td>
<td>14</td>
</tr>
<tr>
<td>Provincial guidelines for online science labs</td>
<td>15</td>
</tr>
<tr>
<td>Submissions re guidelines</td>
<td>16</td>
</tr>
</tbody>
</table>
Summary

This discussion paper, written for the BCcampus Articulation and Transfer of Remote and Web-based Science Lab Curriculum project, defines some terms used in distance education and gives a quick perspective on the use of distance education technologies around the world. A set of learning objectives for science labs in general and some statistics on the success of transfer students in B.C. are used to consider whether online labs would necessarily have different learning objectives. Issues that have arisen around the province about online and remote labs (and some possible solutions) are discussed. These issues are categorized as: academic integrity, skills development, cost, and transfer considerations.

Four possibilities for guidelines are put forward for discussion - no doubt there are others.
Introduction

Post-secondary distance education is not new to British Columbia. Prior to the establishment of the B.C. Open Learning Institute (O.L.I.) in the early 1980s, institutions such as North Island College offered courses through paper distance course packages (with telephone tutors). OLI later became OLA (the B.C. Open Learning Agency) and eventually British Columbia Open University (BCOU). In 2005, BCOU became a part of the newly created Thompson Rivers University (TRU) and is now known as Thompson Rivers University, Open Learning or TRU Open Learning (TRU-OL). Distance science courses from OLI, OLA and BCOU have had transfer credit within the province for their courses in the same manner as those from any other college or institution. Lab courses or lab portions of courses were generally done as on-site labs which meant that students either attended a number of weekends or a week long summer session at a college in the province, doing the same labs as traditional students.

The advent of technology has changed distance education. Where once most courses were print based with the possibility of audio or video as secondary – sometimes even primary – source material, now most distance education is online with an array of technologies to enhance the distance education experience. Simulations, videoconferencing, video-streaming, discussion boards, e-mail, and chat rooms are only a few of the new ways of communicating through the Internet. These have enhanced distance education and allowed communication and interaction not just between instructor and student but between students. The nature of communication in the “information age” is changing rapidly; what was once considered to be leading edge is now commonplace. New technologies currently allow the delivery of high quality science labs to distance education students. These labs may differ somewhat from traditional labs but well-designed online labs can fulfill laboratory learning objectives in much the same way as on-site labs.
The Web-based Associate of Science project in British Columbia is a 5-year endeavour to adapt science curriculum - including labs - for web-based delivery. It is funded by the Inukshul Wireless Fund and BCcampus and involves North Island College, College of the Rockies, Thompson Rivers University Open Learning, Kwantlen Polytechnic University and Tatlayoko Think Tank – an “e-learning company. The aim of this discussion paper is to present information about the different approaches being taken in the development of online labs in both B.C and other parts of the world, about the challenges involved in online labs and to stimulate discussion on possible guidelines to ensure such labs can gain, or retain, transfer status within the province.

Definitions
Terms used to describe non face-to-face laboratory sessions include “virtual”, “simulated”, “online”, “remote”, “web-based”, “distance” – and there are probably many definitions for each of these terms. For the purpose of this discussion paper “virtual” and “simulated” will be considered to be synonymous. Although often “online”, this is not always the case as virtual and simulated lab exercises could be accessed from discs, DVDs etc. and not necessarily just over the Internet. Both “remote” and “distance” could be said to describe any lab, including virtual, simulated, online or a lab kit set that is not used on site or in the face-to-face presence of an instructor. Thus a field trip with an instructor present is not considered to be a distance or remote lab, but a field trip without an instructor present would be classified as distance or remote. The Web-based Associate of Science project uses the combination “remote web-based” to describe an enriched online environment using remote sensing and control technology. The phrase “remote and web-based” will be used here to refer to initiatives in B.C. (This is more correctly “remote and/or web-based” and thus covers remote field trips as well as labs that use kit sets). As “online labs” is often used outside of B.C., that term will also be used in a general sense.
Perspective on remote and web-based labs

Remote and web-based labs or online science labs are generating a great deal of interest around the world and such labs are becoming main-stream. A literature review, undertaken as part of this BCcampus Articulation and Transfer of Remote and Web-based Science Lab Curriculum Project, found universities, colleges, and institutions in Canada, the U.S., Europe, Asia and Australia actively engaged in online labs. While this review, available through a link on the Web-based Associate of Science web-site http://rwsl.nic.bc.ca/ (under Research Papers on the top right-hand column) does not cover every online science course or web-based project, it does give an insight into the widespread use of technology and the diversity of offerings now available as lab experience for science students. Nor are these technologies being reserved only for remote labs. Instructors are finding a use for simulations in face-to-face labs, as demonstrations in lectures, as pre-lab instruction and as post-lab review. Universities and colleges are accessing specialized instruments at other institutions, employing similar remote sensing and control equipment as that used for distance labs, and thus allowing their own students the access to advanced instrumentation that they normally would not have.

Although really outside the scope of this discussion paper, two other examples of the role of technology in practical education are worth mentioning: aviation and medicine. Airplane simulations are widely used by airlines and air forces as they allow advanced training in a safe and cost-effective way and aircraft simulators are now very like the real thing. Simulations also now play a valuable role in medical education, especially for surgical skill development. Medical students are able to repeat surgical steps a number of times, practicing the necessary skills before operating on a real patient. These skills are not dismissed because they were obtained virtually. Although not at this level, a number of science educators are developing relatively sophisticated online products that can help students gain skills in lab procedures.
Learning objectives for labs

Are the learning objectives for online labs any different to those for traditional on-site labs? Is there a recognized set of learning objectives already in use for labs? Should there be provincial standards or guidelines for transferability for all lab courses in B.C.? These are questions that could be discussed in science departments and at articulation committee meetings.

The 2005 National Academies (of Science, Engineering and Medicine) 236 page “America’s Lab Report: Investigations in High School Science” (1), resulted from a National Science Foundation request to the U.S. National Research Council to examine the current status of science laboratories and develop a vision for their role in high school science education. Although the report focuses on high school labs, the seven goals for laboratory experiences –given below - are just as relevant to laboratory education in B.C.’s colleges and universities.

- enhancing mastery of subject matter;
- developing scientific reasoning;
- understanding the complexity and ambiguity of empirical work;
- developing practical skills;
- understanding the nature of science;
- cultivating interest in science and interest in learning science
- developing teamwork abilities.

A possible eighth goal could be
- using real world data.

Are all these goals met equally in every lab? Obviously not. For some lab courses one or more of these goals may be more important than others. Different courses and different levels have different learning objective priorities.

Courses from different institutions but with the same provincial transfer credit differ in how much weight is given to any one priority. Students may develop better teamwork ability when the experiment is done in pairs or groups but do they attain the same skill level when only one of the pair or group actually does the titration or dissection? Sections of the same lab course at the same institution but taught by different instructors also vary - one instructor emphasizing a particular aspect of lab technique more than another instructor. Yet despite all these variables, students in the B.C. system who transfer to another institution manage to adapt to the different lab culture of their new institution with few problems.

Reports available through the British Columbia Council on Admissions and Transfer (www.bccat.bc.ca/publications - under “Student Mobility and Success”) show degree completion rates (“Profile of BC College Students Admitted to Simon Fraser University 1998/99 to 2002/03”).(2) The SFU report also comments on what it calls “transfer shock” – i.e. a decline in the admission grade point average compared to the GPA at the end of the first semester, a consequence of the difficulty students may experience when they move from one educational institution to another. However, by graduation, differences between admission and graduating GPA decline or, in some cases, almost vanish. As the graduating GPA is cumulative, an initial larger transfer shock still affects the graduating GPA even if students are performing at the level of their peers at the time of graduation. Similar results are shown for students who transferred to UBC (“Profile of BC College Students Admitted to the University of British 2001/02 to 2004/2005”).(3)

The UBC and SFU reports (as well as similar reports for the University of Victoria and the University of Northern B.C. – also available on the BCCAT website at www.bccat.bc.ca/publications/index under “Student Mobility and Success”) give

(2) http://www.bccat.bc.ca/pubs/SFUProfile0203.pdf
(3) http://www.bccat.bc.ca/pubs/ubcprofile4.pdf
details of GPAs earned by transfer students from both public and private institutions in B.C. for the forty-five or so most common courses taken by transfer students. The somewhat lower GPAs generally attained by transfer students do not tell the whole story as they do not include any data on possible “transfer shock” etc. nor do they take into account the generally higher GPAs of students entering university directly. However, these reports do indicate that the transfer process works relatively well in British Columbia.

Although a much smaller percentage of transfer students attain a science degree compared to arts or business administration (8% B.Sc. vs. 58% B.A. or 13% B.B.A in the SFU report), the GPA data for science transfer students is comparable to that in arts or commerce. It does not seem that doing a different set of labs at one college with different instruments, different lab procedures and different lab priorities causes insurmountable problems on transfer. Would we not be able to apply this same finding to students who transfer after doing an online or remote web-based lab?

Issues - and possible solutions

The following issues are noted from the literature review (see link at http://rwsrl.nic.bc.ca/) and/or from conversations with faculty around the province. Other issues may arise and will need to be addressed as science educators in B.C. become more aware of the possibilities of online labs

Issue #1 - academic integrity

Online education appears to have a unique set of problems around academic integrity. How does an institution ensure that the student enrolled in an online course is actually the student writing the papers and doing the assignments? But this issue can be just as much a problem for face-to-face classes. It is possible to buy research essays over the Internet, to have someone else do your assignments and cheating also occurs during invigilated exams. Most distance
courses use various strategies to ensure academic integrity and to combat the “easier to cheat” perception: students are usually required to take an in-person final exam at a designated centre or to arrange for an approved independent invigilator for a final exam written in their own community, and there is also often a requirement that to pass the course a student must pass this final invigilated exam irrespective of assignment marks.

Is cheating really more of a problem with students in a remote/web based lab? Remote students are often just that – remote! They are unlikely to have friends, siblings or classmates who did the lab last semester or last week so there is no-one available from whom they can “borrow the lab write-up”. Plagiarism via the Internet is just as available for a student in B.C. from Cortes Island (population 850) doing an online first year English course as it is for an English student at university or college. But if that same Cortes Island student is doing a first year physics lab online, how likely are they to find someone willing (and able) to do the labs for them? Faculty teaching remote labs report that they get to know the students very well by email, telephone etc. and have confidence about knowing when students are doing the labs themselves.

Verification techniques – special passwords, webcams etc. - have been suggested and as these and other technologies become more widely available “invigilation” of online labs may be possible. Whether this is desirable or worthwhile is another area for future discussion.

The topic of academic dishonesty in online courses, although not particularly about science labs, has been discussed in recent educational journals. A 2008 paper(4) from the Sloan Consortium reported that, contrary to expectations,

results from a study involving over a thousand online undergraduate students suggest factors known to contribute to academic dishonesty in face-to-face classes have little influence in online courses. The results also suggest that future research needs to consider whether students who engage in online learning have different ideas about what constitutes cheating. The first five articles in the latest (June 2009) (5) issue of the Journal of Online Learning and Teaching address a number of issues of online academic dishonesty including authentication strategies and other possible solutions - again not specifically in the context of science labs. The abstracts of these articles are available and a link(5) is supplied for the full article (either HTML or PDF) in each case.

**Issue #2 – skills development**
Some concern has been expressed about whether students can develop adequate hands-on skills from remote or online labs. Depending on the actual laboratory course, there are various solutions to this perceived problem. As mentioned under “learning objectives”, gaining hands-on skills is just one of the objectives for labs, and its importance varies from lab to lab. Although for some types of courses a totally simulated series of labs may be acceptable, many other lab courses would be better served with a combination of simulation and another approach such as a lab kit. Simulations or virtual labs are not being considered for the Web-based Associate of Science Project being developed through BCcampus. Instead, this project will use a RWSL (remote web-based science labs) approach where students through remote access and control over the Internet, use actual lab equipment and collect real data, in real time. Lab kits or field work may also be included. This combination approach should ensure that students have the necessary skills to continue on to subsequent lab courses.

The skills that students obtain remotely may not be exactly the same as the skill

set from a traditional lab but will these students be any more disadvantaged on transferring to another institution than other transfer students? How long does it take to learn to use a microscope if you have previously used a remote set-up with a microscope? Can a student who has used a lab kit titration set-up (and maybe also a simulation) manage a titration in a traditional lab? Developers of remote and online labs aim to give the students as close to a “real” experience as possible. Surely it is possible to evaluate how easily students can adapt their virtual skills to actual situations.

Table 1, adapted from an engineering education article\(^6\) discussing key issues in virtual/simulation labs and remote laboratories, lists some of the advantages and disadvantages of different ways of providing a laboratory experience.

### Table 1. Comparison of face-to-face and online labs

<table>
<thead>
<tr>
<th></th>
<th>Traditional Lab</th>
<th>Online Lab (RWSL)</th>
<th>Simulation Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>High</td>
<td>High – but fewer class sets</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>required</td>
<td></td>
</tr>
<tr>
<td>Equipment &amp;</td>
<td>Required</td>
<td>Equipment required;</td>
<td>None</td>
</tr>
<tr>
<td>facilities</td>
<td></td>
<td>smaller lab space needed</td>
<td></td>
</tr>
<tr>
<td>Hands-on</td>
<td>Best exposure</td>
<td>Close to traditional</td>
<td>Virtual</td>
</tr>
<tr>
<td>experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reality and</td>
<td>Very high</td>
<td>Close to traditional</td>
<td>Low for 2D –</td>
</tr>
<tr>
<td>control</td>
<td></td>
<td></td>
<td>can be realistic for 3D</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Usually limited</td>
<td>Could be available 24/7</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Supervision</td>
<td>Instructor</td>
<td>Online chat/e-mail telephone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamwork</td>
<td>Students can</td>
<td>Both independent and groups</td>
<td>Independent</td>
</tr>
<tr>
<td></td>
<td>work in pairs</td>
<td>possible</td>
<td></td>
</tr>
<tr>
<td>Safety issues</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Equipment</td>
<td>Equipment and software updating</td>
<td></td>
</tr>
<tr>
<td>Educational</td>
<td>Real experience/</td>
<td>Interaction with real</td>
<td>Conceptual</td>
</tr>
<tr>
<td>benefit</td>
<td>practical skills</td>
<td>equipment via online</td>
<td>learning</td>
</tr>
</tbody>
</table>

Issue #3 – cost

Two very different perceptions of the cost of remote/online labs seem to exist. Some believe that such labs are being promoted because they will be inexpensive to run (and therefore all labs in the province will be phased out and science labs offered only online!) Those working to develop remote/online labs understand that this is far from the truth. The type of distance labs being developed in B.C. involves both remote web-based labs and lab kits. RWSL is not inexpensive; equipment costs are high and development time (and therefore cost) is also high. Once these labs are developed there are ongoing costs of equipment replacement, technician time and software updating (lab kits also have ongoing costs.) As students access the robotic equipment of RWSL one at a time, it would be totally unworkable for all the students in the province to use this technology instead of face-to-face labs. The reason for development of RWSL (and lab kits) has nothing to do with “getting rid of face-to-face labs” but all to do with providing students who live in remote communities or students with family care/ employment responsibilities the opportunity to access a full range of post-secondary educational opportunities that would otherwise be unavailable to them. Traditional scheduled science courses and labs effectively disenfranchise these students at a time when we should be looking at ways to increase numbers of science students. RWSL is about access for B.C. students; some of these students will end up in universities across the province continuing their science studies.

Instructors who have taught an online course know that it is as much – if not more – time consuming than a regular course. The same holds for RWSL and other online labs. Lab supervisors are still needed; there will still be student questions to be answered and lab reports and quizzes to be graded. For the instructor face-to-face classes or labs are somewhat forgiving; you can stop the class or lab at any time and remind the students of a particular concept or introduce new material relevant to a question that has just been asked. The same is not true for remote/online classes and labs. The order of topics has to
be considered very carefully, organization and preparation become extremely important, and ongoing updating is essential.

**Issue #4 – transfer concerns**

A number of problems have been identified around the issue of transfer. Most of the science courses being adapted to online use already have transfer credit and in many cases have had such transfer credit for twenty or thirty years. What happens if a student now takes this established course by a different delivery method? Institutions do not differentiate by mode of delivery on a student transcript – and articulation involves content, not delivery method. Will only new courses have to be identified as online courses during the articulation process? What about students who transfer to B.C. universities from other provinces or other countries? Will the university ask each such student if their courses and/or labs were online or face-to-face or will the university just accept the transcript? Should our universities be treating B.C. transfer students any differently to students from outside the province? How do B.C. universities ensure the quality of the labs – traditional or online - in the science courses on an international student’s transcript?

Some institutions include lab and lecture in one course, others separate these into a lab course and a lecture course with different course numbers for each. Does this mean that a science course with a lab as part of the course is not subject to the same transfer concerns as a lab course with its own course number? Does a course where only some students are online get treated differently to a course where all students are online? In most science courses the lab is worth 20% – 25% although students are usually required to pass both lab and lecture portions to pass the course. Failure rates for the lab portion of the course are usually low (generally around 5%); if students fail the lab it is often because they didn’t attend the lab or didn’t hand in the lab report. Lab exams are usually designed so that students who did not attend the lab have little hope of
passing but students who do attend the labs should be able to pass. Would this be any different for students who do labs via RWSL or with lab kits?

One solution to all these issues is for remote and/or web-based labs to be treated in the same way as other labs. If an institution’s education council or senate approves a course, it could be accepted for transfer in the normal manner.

**Provincial guidelines for online science labs**

Below are four variations for the possible establishment of provincial guidelines. Discussion is not limited to these four and other suggestions are welcome. It should be noted that acceptance of any course for transfer still remains the prerogative of the receiving institution irrespective of whatever principles or guidelines become established.

1) **No guidelines**

Do we even need a set of guidelines? Articulation is about content of a course, not about method of delivery. In the late 1960s and early 1970s when the B.C. college system was starting, the (then) three universities were asking colleges for details on who was teaching transfer courses and what their qualifications were. The colleges responded that they had internal qualification guidelines (now part of their Education Council policies) which were readily available to be seen but that they would not respond to requests for individual curricula vitae of the faculty teaching transfer courses. This was a principle of college autonomy - and the universities accepted this. The system as set up was - and still is - based on trust. It is working well and is considered a model for other provinces and other countries. If the colleges’ own educational councils approve online/remote labs as educationally sound for their students then should not this be accepted in good faith as are so many other aspects of transfer credit?

2) **General guidelines for all science labs**
A set of general guidelines could help all institutions in establishing quality labs - whether traditional or face-to-face. Details of the guidelines would need to be determined. Following the guidelines would not be a guarantee of transfer credit as acceptance of any course for transfer would still remain the prerogative of the receiving institution.

3) **General guidelines for online/remote science labs**
As traditional face-to-face labs are well established in the province, any guidelines established would only apply to the online/remote and other new technologies. Details of the guidelines would need to be determined and following the guidelines would be no guarantee of transfer credit.

4) **General and specific guidelines for online/remote science labs**
Guidelines for online/remote labs need to be more than general and should be specific for each discipline and for courses and levels within each discipline. Once general guidelines are established, discipline articulation committees could choose to follow those guidelines or establish their own set of more specific guidelines for different courses and different levels. Once again following the guidelines (specific or general) would not be a guarantee of transfer credit.

**Submissions re guidelines**
The BCcampus Articulation and Transfer of Remote and Web-based Science Lab Curriculum Project would like to have your opinion on the issues presented in this discussion paper. What do you think about:
- guidelines or no guidelines?
- what should guidelines be based on? (maybe the goals on page 7?)
- guidelines for all labs or only online/remote labs?
- general or discipline/course-specific guidelines?

as well as any other issues around this topic. Please e-mail Penny Le Couteur at plecoute@capilanou.ca before Sept 30th 2009 with your comments and suggestions.