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THE GAME CHANGERS IN ONLINE LEARNING SERIES

Case Study #2:
The Colorado Community College System

Online. Collaborative.
Lab-based. System-wide.
Inter-state/International.

Eight key features of the Colorado Community College Systems (CCCS) online labs for teaching science which, taken together, are game changing:

- common science curriculum within all 13 colleges in the CCCS
- online science courses available to any student registered with a CCCS college
- complete associate science degrees available fully online (as well as on campus)
- integrated use of remote labs and home kits for science lab work for online learners
- consortium approach to the design and evaluation of remote labs and remote experiments
- remote labs shared or cloned across several states/provinces
- substantial federal and foundation grant funding
- major potential for expansion of both online labs and online lab experiments

THE COLORADO COMMUNITY COLLEGE SYSTEM

The Colorado Community College System (CCCS) consists of 13 community colleges across the state of Colorado, serving more than 160,000 students annually. The Colorado Community Colleges are accredited by The Higher Learning Commission (a commission of the North Central Association of Colleges and Schools).

CCCOnline, a consortium comprised of the 13 community colleges in the Colorado Community College System, offers courses to students seeking online classes, although students must register with one of the 13 colleges. Individual college campuses also offer their own online courses. The courses available through CCCOnline are transferable to any of the 13 member home colleges in the Colorado Community College System and any public four-year state college. Students seeking the Associate of Arts (AA) or Associate of Science (AS) degree programs can complete these entire degrees by taking CCCOnline classes through their home college.

CCCOnline currently offers fully online first and second year science courses (physics, chemistry and biology), using a combination of online learning and home kits. In 2012, it introduced remote labs enabling students to do some of the experimental work fully online.

STUDENTS

CCCS is the largest, fastest growing system of higher education in Colorado, providing educational opportunities for 160,000 students per year at its 13 colleges. Over the past four years, CCCS has added nearly 41,000 students. In 2011-2012, the headcount of students in CCCS grew by 10,000 students and full-time-equivalent students grew by 5,900. CCCS increased the number of degrees awarded by 27 percent from four years ago.

CCCS colleges transferred more than 10,200 students to four-year institutions in 2011-2012. Students who transfer perform as well or better than their counterparts who started at their four-year institutions—both in terms of their grade point averages and graduation rates.

A student taking a full-time load of 30 credit hours a year (10 courses) at a CCCS college will pay US$3,176 in tuition. This is half the tuition cost at a public, four-year institution in the state and one third the cost of a public research institution.

Over past two years, CCCS colleges created 170 new programs in response to the needs of business and industry for high-paying jobs in high demand. When students are awarded a degree at a CCCS college, their earnings increase a minimum of 32 percent and up to 100 percent if they earn a degree in the health sciences field, which represents half of CCCS' degrees awarded.

There are approximately 40,000 students enrolled in CCCSOnline courses. Overall, there are approximately 400 students per semester taking online science courses (roughly 50 students per semester taking online physics, 100 taking online chemistry and just over 200 taking online biology). Students from different campuses are aggregated into classes of approximately 25 for the online science courses. The main demand comes from students in the smaller colleges or in more rural locations, who cannot access easily on-campus science courses.

ORIGINS OF THE PROJECT

The CCCS remote labs are part of the North American Network of Science Labs Online (NANSLO) project. NANSLO has been created to help low-income, first generation college students. These are at risk of failing to complete their degrees or to pursue science-based careers, due to challenges such as work and family obligations, or living in rural areas that limit their access to traditional classes.

NANSLO is building on the open educational science courseware and the Remote Web-based Science Laboratory developed by members of BCcampus, a consortium of 25 postsecondary institutions in British Columbia. BCcampus funded colleges in British Columbia to develop online biology, physics, geology and chemistry courses and to design, acquire, and operationalize a Remote Web-based Science Lab to fulfill the lab component of these courses. BCcampus licensed these courses for

reuse and sharing via Creative Commons licensing.

The Western Interstate Commission for Higher Education (WICHE), a nonprofit organization with 15 member states, is the coordinating partner and fiscal agent for NANSLO. BCcampus, North Island College in B.C., and the Colorado Community College System (CCCS) are WICHE's major partners for this work. North Island College provides recommendations for Web-based science lab equipment, infrastructure and system architecture to WICHE and CCCS. In addition, the Colorado School of Mines, the University of Wyoming, Montana State University, Great Falls College of Technology and Laramie County Community College are also in the consortium as members of NANSLO's advisory board and discipline panels, as well as potential sites for the expansion of NANSLO.

As a member of the NANSLO consortium, CCCS is offering gatekeeper courses—biology, physics and chemistry courses—replicating the remote laboratory currently in operation at North Island College in British Columbia. North Island College is playing an integral role with WICHE and CCCS as it replicates these courses and laboratories so that the project can be implemented as efficiently as possible.

THE REMOTE LAB EXPERIENCE

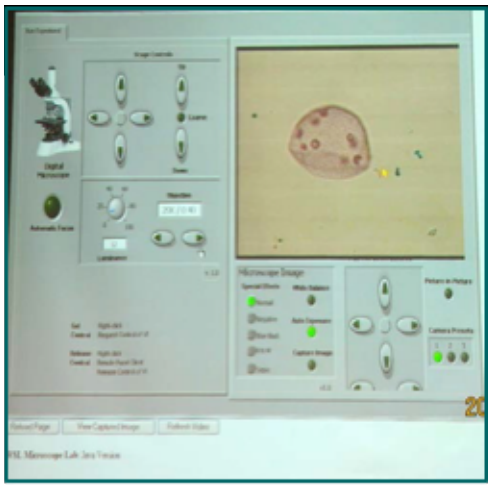
The project started in Spring of 2012, so in Spring of 2013 it is in its fourth semester.

A remote lab based on the design originally developed at North Island College has been set up at CCCS's headquarters in Denver.

- control the lab equipment remotely, using commercially available digital control technology;
- see the experiment in real time via a bank of video cameras that the students can control;
- talk to other students or the lab assistant during the lab session;
- download data generated by the experiment.

Figure 1: The remote lab at CCCS HQ, Denver (The biology equipment is on the top bench, the chemistry spectrometer and other equipment is on the middle bench, and the physics air track is at the front of the room).

Figure 2: Student desktop screen view for a biology experiment (Controls are on the left and bottom right, and the top right hand window with the protozoa is a video direct from the microscope, the magnification of which will change as the microscope is adjusted by the student.



Currently, there is

- one physics remote lab experiment using an air track,
- two for chemistry using a spectrometer and a temperature controllable cuvette holder, and
- two for biology using a more powerful (600x) microscope than the optical scope in the home kit.

However, the project is still very much in a developmental stage, with new experiments being developed. It is anticipated that up to 20-30% of the lab work required for the first year physics and chemistry classes, and up to 50% for the biology classes, will eventually be available via the existing remote lab set-up. Furthermore new and better remote controllable laboratory equipment is regularly being identified.

Students log in to schedule a two hour session, with up to four students in any single session. Students are encouraged to discuss the experiment and the results with the other students participating. A lab assistant is always available during experiments and may help with setting up equipment, but the students are expected to work out the procedures and interpret the meaning of the results.

CCCS online students taking science courses are also issued with home lab kits from a commercial supplier. The remote labs are not intended as a full replacement for the lab kits, but it is hoped that increased use of remote lab experiments will enable the cost of the home kits to be reduced.

CURRICULUM AND COURSE DESIGN

The remote lab experiments are an integral part of the first semester science curriculum, and will be extended into the second semester

courses. There is a common curriculum for all the colleges across the system, with a large database of courses. Proposals from individual colleges for new courses are reviewed by a State Faculty Curriculum Committee and finally signed off by the State Council of Vice-Presidents Academic. All courses have defined topics and learning outcomes/ competencies.

For the online science courses, a detailed analysis of each course's curriculum is undertaken by staff at CCCS. The courses are analysed using a spreadsheet that divides a topic into student activities that are matched to the stated course competencies. It is at this stage that the experiments for the remote lab already developed at North Island College, and increasingly by local CCCS staff, are fitted into the curriculum, usually replacing a home kit experiment. Assessment is based on a combination of online quizzes, lab reports and exams taken at the home college.

Online science courses are designed by a course team consisting of a subject matter expert (usually from one of the colleges) who is paid a small fee, an instructional designer, and an associate dean from CCCS.

FUNDING

Students pay a higher tuition fee (an extra $45 per course) for online courses than for campus courses in the CCCS. The tuition fee for the online science courses is the same as for other online courses, but students pay an additional $200-$300 per subject for the home lab kit.

Tuition fees are split 50-50 between the home campus and CCCOnline, but the home campus retains 100% of the state funding per FTE for any online students taking CCCOnline courses. The home campus provides enrollment services and manages applications for financial aid.

Through the NANSLO project, CCCS has also received substantial grant money for establishing the remote labs and for building its partnership with BCcampus. CCCS received $749,994 for 15 months through a NGLC grant (funded by Bill and Melinda Gates Foundation/ William and Flora Hewlett Foundation) to the NANSLO project to get the remote lab project started, and a further $5 million for the continuation of project from a grant to NANSLO from the U.S. Federal Dept. of Labor, for industry-based, job-related projects in community colleges.

The remote lab requires a full-time director with a science teaching and IT background, a lab manager (with a Ph.D. in biology and a strong IT background), and three part-time lab assistants (undergraduate students from the Colorado School of Mines).

NEXT STEPS

Currently the CCCS remote lab is working at 50% capacity. There are several ways in which utilization can be increased:

- More students, as second semester courses get added.

- Through a move to hybrid learning in the Allied Health program. Currently students using the remote labs are enrolled in the fully online science courses. However, the Allied Health program is moving towards a hybrid model and remote labs could play an increasing role in this program.
- More experiments. Several strategies are being used to develop more experiments around the existing remote lab equipment:
  - ◊ workshops for CCCS instructors to help design new experiments;
  - ◊ development of a 'sandbox' for instructors to pilot new experiments;
  - ◊ suggestions from partner colleges in British Columbia, Montana and Wyoming, and the Colorado School of Mines for new experiments.
- Additional lab equipment around which new experiments can be designed.
- Use of application virtualization software (such as Citrix) that will optimize the connection to the remote labs for each student, and will allow Windows, Mac, Linux and other platforms to access the remote labs equally well. (Currently, access is limited to Windows computers only.)

In addition, the lab is moving in the summer to larger premises, and a large investment is being made in a more powerful and more secure server and software, and more flexible and reliable control equipment.

Discussions are under way to replicate and extend the reach of remote labs through the NANSLO project. It is planned to have two development/ sandbox labs (one in Denver, the other at North Island College, British Columbia) and three production/teaching labs (Denver, NIC and Montana.) The production labs will serve colleges in other states (e.g., NIC will support colleges in Alaska) as well as their own.

Thus it is important to stress that although the CCCS remote lab is fully operational, it is also very much still in a developmental stage, with plenty of room for growth, by:

- reaching more and different kinds of students within Colorado;
- increasing the range of experiments using existing equipment;
- adding new lab new equipment;
- extending existing or new remote labs to more colleges and states;
- adding new subject areas or programs.

EVALUATION

An independent company (Inverness Research) conducted an evaluation study in November 2012 as part of the NGLC grant. The report is prefaced as follows:

The NANSLO project was extremely hard pressed to achieve its proposed

goals within the short timeframe [15 months] allowed by the grant. Seeing the NANSLO project as initial development and piloting - rather than the wider implementation of a well- tested educational technology - is critical to interpreting the results of the study.

In particular, they found that instructors had practically no prior first-hand experience using remote lab equipment or doing the lab exercises associated with it. Thus there was a steep learning curve for instructors as well as students. The study also identified problems with lab reports in general, both for conventional lab based classes as well as the remote labs.

The main advantages of a remote lab over home kits were identified as:

- Authenticity ('it does look like the real thing'). This becomes more important as science increasingly depends on the use of remote instrumentation.
- Precision: the remote lab equipment provides more precise and accurate data than the home kits.
- Collaboration: students can work together in the remote labs, whereas with home kits they have to work alone.
- Support: the availability of a lab technician during the remote lab experiments provided greater support than they could get with the lab kits.

Nevertheless, there was agreement by instructors and students that remote labs, at least in their current form, are best used in conjunction with home kits. There will be further evaluations as part of the Dept. of Labor grant funding as the project develops.

SUSTAINABILITY

It is still too early to come to a judgement about the long-term sustainability or business models for remote labs. They are very much a work in progress and grant funding has been essential to get the projects started. However, the main costs are in the initial set-up of the control equipment, scheduling software, server capacity, and lab equipment hardware.

Many of these costs have now been, or will shortly be, covered. Thus the main fixed costs are already in place.

KEY FEATURES OF THE CCCS ONLINE LABS

What follows is a summary of these developments in the form of a table which looks at three questions:

What is a student at CCCS able to do?

Why is this good for students? and

How does CCCS make it happen?

A CCCS student is able to...	Why this is good for students	How CCCS makes this happen
Take science courses online Students can take science courses, including experimental work, fully online or, in the future, in hybrid mode.	Students who are working, or with young families, can take the necessary foundation courses in science needed for jobs in health and other related sciences for which there is high demand for qualified workers.	CCCS uses a combination of a learning management system (Desire2Learn), home kits and remote labs, and course design specially adapted to the needs of online science teaching.
Do experimental work online Students can use a combination of home kits and remote labs to conduct real experiments.	The remote labs provide more authenticity, precision and access to specialized equipment than the home kits, and the remote labs and home kits enable students who cannot easily access a campus lab to take science subjects.	CCCS partnered with other organizations that had already created remote labs and has developed a relationship with a commercial supplier of home kits. It has covered start-up and development costs by attracting major national grants.
Transfer in their online courses into their home campus and into state universities Students can combine online learning with campus-based courses.	Online courses are treated the same for credit as classroom courses, and students can automatically upgrade to a four year program on successful completion of the appropriate college programs.	There is a state-wide transfer and articulation system, with common core curricula and a standardized process for course and program approval.

Afford their studies Students pay a total of $3,176 a year tuition fees for a full load of 10 three credit courses. There are additional fees for online courses ($45 per course), and for online science courses the home kits cost an additional $200-$300 per subject.	Most students qualify for federal and state financial aid. No travel or commuting costs for online students.	By having a centralized system of curriculum planning and standardized course competencies/ outcomes, programs are accredited irrespective of the delivery method, thus qualifying students for financial aid.
Improve their career prospects	When students are awarded a degree at a CCCS college, their earnings increase a minimum of 32 percent and up to 100 percent if they earn a degree in the health sciences field, which represents half of CCCS' degrees awarded.	Over past two years, CCCS colleges created 170 new high-demand, high-wage programs in response to the needs of business and industry. Offering online science courses brings in an additional 400 students per semester to science programs, helping meet a national need.

THE SEVEN KEY ENABLING FACTORS

In exploring with the senior leadership and key operational staff of CCCS why these developments have occurred, we identified these factors:

1. **Strong internal leadership at the system level,** supporting online learning and in particularly the remote lab project;
2. **Strong partnership and collaboration,** building on the work of earlier developments outside the state and extending and sharing the experience with other colleges in other jurisdictions;
3. **Generous grant funding,** by relating the use of remote labs to national needs in the area of science and technology training, and by developing a broad inter-state approach to online science teaching with possibilities of further transfer;
4. **A system-wide approach to online learning.** Having central online development and delivery in collaboration with the local colleges results in economies of scale in filling online science courses, the transfer of courses within campus programs, and quality assurance standards for the online lab work;

5. **Integrated course design.** The remote labs meet a specific need within the online science courses, providing experiments that cannot be done as easily or as well through home kits, and contributing to the development of defined competencies for courses;
6. **High quality, science-based local staff** have been essential for problem-solving, further development, and the effective management of scheduling and delivery;
7. **Technology.** The availability of commercial, advanced control technology, the design of user-friendly interfaces for the experimental work, access to higher end scientific equipment, convenient online access from home, and a growing trend towards remotely operated lab technologies in science are all critical factors in enabling this development.

These seven enablers have provided the base from which innovative and high quality online science is being developed in the Colorado Community College System as one strategy for meeting the shortfall of students with basic science and technology qualifications.

These materials are based on the March 2013 visit to CCCS's offices in Denver where extensive briefings, demonstrations, and interviews took place with:

- Dr. Rhonda Epper, Assistant Provost, Colorado Community College System
- Dr Dan Brannan, Project Manager for North American Network of Science Labs Online, and Director of the CCCS remote lab project
- Patricia A. Shea, Director, Western Alliance of Community College Academic Leaders, Western Interstate Commission for Higher Education, and also Director, NANSLO Project
- Dr. P.J. Bennett, Remote Lab Manager, CCCS