**Distance Learning – the Final Teaching Frontier? A Symposium with Experienced Chemical Educators in Distance Learning.**

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**Abstract:**

"Innovations in teaching chemistry" certainly describes the efforts applied to distance learning in undergraduate chemistry courses. This symposium consisted of two presentations and one panel discussion with chemical educators sharing their experiences and ideas regarding critical parameters of student success such as assessment, best practices, technology tools, and delivery methods of hands-on lab experiences. The sessions highlighted two different modalities for offering hands-on experiences for laboratory activities to educators offering distance learning chemistry labs. The panel discussion allowed for presenters and participants to discuss additional aspects and challenges of distance learning chemistry courses. The summary report of experiences and ideas shared during the symposium and a list of distance learning resources will be shared through Two Year College Chemistry Consortium ($2YC_3$) *Resources for Excellence* Workshops on distance learning and published in the $2YC_3$ *Chemistry Outlook*.

**Introduction:**

Chemistry has followed other academic disciplines into the distance learning environment. With the breakneck advances in technology and new web tools, increases in online chemistry course offerings or open courseware[1] have followed at both two and four-year colleges[2]. For an instructor new to online teaching, there is a new and sometimes steep, technological and pedagogical learning curve since the traditional face-to-face (f2f) teaching and learning process differs greatly in an online format. A number of reports and workshops offered by online learning consortiums[4] document the evolution of online instruction in chemistry[3] With advances in technology, the methods to carry out best practices in distance learning are ever evolving. The generally asynchronous nature of distance learning must provide for alternate methods of presenting materials for student engagement, communication and assessment while maintaining the checks that support academic honesty. Moreover, with chemistry courses, a laboratory component is an integral part of the learning process and the American Chemical Society (ACS) advocates for hands-on laboratory learning experiences over computer-simulated activities[5].

This report documents the information shared at the distance learning symposium (~40 attendees) presented at the 195th $2YC_3$ conference at MiraCosta College CA in March 2012. This symposium was organized to help chemistry instructors interested in online teaching meet and learn with other community college educators experienced in distance learning. The experiences of chemical educators from Anoka-Ramsey, Portland and MiraCosta College are similar, having developed their course materials for the online environment and particularly for the development of a hands-on distance learning laboratory component. A resource list of supplemental materials and internet links is found in the Appendix.

**Presenters**:

***Lance Lund*** (Anoka-Ramsey CC lance.lund@anokaramsey.edu) has taught chemistry since 1988 and online since 2008. He presented his development and implementation of a totally online introductory chemistry class including hands-on distance labs kits, developed in-house.

***Kathy Carrigan*** (Portland CC kcarriga@pcc.edu) has taught chemistry since 1997 and online since 2007. She presented her use of a hands-on commercial lab kits for totally online GOB (general, organic, biochemistry for allied health) and introductory chemistry courses.

***Panelists***: In addition to Lance Lund and Kathy Carrigan, the panel included ***Carmela Byrnes*** (MiraCosta College, cbyrnes@miracosta.edu) who has taught chemistry since 1999 and online for a lecture-only course since 2009 and ***Jim Julius*** (MiraCosta College, jjulius@miracosta.edu), the Faculty Director for Distance Learning facilitating the implementation of instructional technology and online educational development. ***Bernadette Harkness*** (Delta College bernadetteharkness@delta.edu), a chemistry instructor new to online teaching and organizer of the symposium, moderated the discussion.

**Online Lectures:**

Learning chemistry content in an online format serves the student by allowing them to access the material at a time of their choice and to absorb it at their own pace. As an asynchronous presentation, the greatest difference for online classes is to incorporate and maintain the communication and engagement in learning between instructor and student and student to student that occurs in the face-to-face (f2f) classroom.

Videos and synchronous help sessions:

While the presenters assigned traditional textbook readings and problems through online homework systems (Mastering Chemistry and OWL), short video recordings for difficult lecture topics were also made available for the students for their review. Videos of worked out solutions were accessible so that the student could see and hear the logic of chemistry problem solving. Camtasia software, with full editing features, was used to produce videos and a lecture capture tool, Camtasia Relay was also mentioned as a source to record the lectures in the on-campus classroom which were later made available for the online students. Jing, a free product, is also available for producing short videos but lack editing features.

One of the most important aspects mentioned was the use of virtual office hours or synchronous online help sessions for students to ask questions and gain feedback on their learning. Email and other asynchronous communication means were used, however, in the f2f classroom immediate feedback from questions and discussion activities is a key teaching/learning experience. Adobe Connect and Collaborate were two synchronous web conferencing tools that were used to facilitate this activity. A suggested requirement was that students attend a certain number of synchronous sessions to maintain their engagement in the learning process.

**Assessment:**

Integrity of the process:

Since most assessments were given online – homework as well as quizzes and semester exams – one of the main concerns in a distance learning environment is the integrity of the assessment process. The presenters suggested ways to encourage academic honesty through syllabus quizzes reflecting integrity statements by students, timed testing, creative quiz questions and a proctored final exam.

Academic honesty:

The presenters recommended using a method to determine evidence of student awareness of the syllabus requirements that include statements of academic honesty. For example, prior to taking any online quizzes or exams, Lance Lund requires his students to achieve a 100% score on a one-time syllabus quiz where they are obligated to type in the answers that are word-for-word statements from the syllabus such as "I will not cheat….." or "I will use only permitted materials…."

Timed testing:

For online quizzes and exams, timed testing was a key feature to facilitate academic honesty. Short but doable time limits can severely restrict use of outside materials since the time does not adequately allow for answer searching by referencing course materials. The student could also be required to use a lockdown browser program[6] while taking these assessments. This would disable web browser functions and other computer applications on the student's computer and so prevent answer searching from electronic documents or via the internet.

Creative quiz questions:

Developing non-searchable creative quiz questions was also suggested. Lance Lund posed questions like "If chocolate with the symbol Ch was similar to calcium, what would be the chemical formula for chocolate nitrate?" Instructor-created questions do require the ability to use the quiz or testing feature of the learning management system (LMS) used to deliver the online content.

Proctored Final Exam:

A strong recommendation was made that a paper final exam be administered by an acceptable proctor, similar to out-of-class testing for students in an on-campus class. It was further suggested that the syllabus specifically state that the final exam grade would be compared to the average of the semester tests. If the final exam grade was ~20% or more lower than the average of the semester exams, the student may be required to retake the online semester exams in a proctored setting. This condition helped to determine if the student had indeed taken the online semester exams without external materials or help. An anecdote was relayed where a student did fall short on the final exam and when prompted revealed that there was a 'lapse in judgment' and other

materials had been used during the semester tests. Alternatively, a passing grade on the final exam could serve as a gateway for successful completion of the course.

**Hands-on Lab experience**:

As part of the complete distance learning course and to follow ACS recommendations for a hands-on laboratory component[5], the presenters shared different methods of providing hands-on laboratory activities. One option included an in-house developed lab kit with a core set of chemical lab equipment with additional items to be purchased by the student. A second option was the use of a commercial lab kit complete with all items. For both presentations, the safety, affordability, and learning outcomes were considered so that the student would have a learning experience as equivalent as possible as to students in the on-campus laboratory. Students who have experienced hands-on lab exercises in a distance learning chemistry course have been reported to achieve equivalent or better success than those in the f2f course[3b].

Safety

Safety is a primary concern when offering complete distance learning chemistry courses since the inherent supervision by the instructor is not available. Both presenters had mandatory safety lectures/videos and quizzes with high minimum scores as an entry for access to the lab exercises. The commercial lab kit manufacturer offers its own safety video and assumed liability of any effects from its lab kit. Additional safety videos are internet-accessible.

In-House Lab kit:

Lance Lund, with the help of chemistry stockroom personnel, presented an in-house prepared lab kit, which included a list of durable items (returnable equipment such as a digital balance, temperature probe, etc) and consumable items (chemicals used then discarded) that would be included for student purchase. The list also included general grocery store items that the student would provide. To keep costs to the student down, the kits were sold for a $75 purchase price and if returned with the durable equipment in tact, the student would receive a $50 refund. Liability was not addressed using in-house prepared lab kits but no issues were reported.

***Examples of laboratory exercises*** that could be carried out with the in-house kit:

- Graphing and Prediction (penny lab)
- Density, Conversions and Significant Figures
- Freezing Point Depression (solute effect on freezing point temperature of snow/crushed ice)
- Paper Chromatography (colors of M&M$^{TM}$ candies)
- Molecular Modeling Lab (used Jmol feature of Chemsketch software to create 3-D images) Student to determine Lewis structure and formula from these images
- Stoichiometry / Limiting Reactant (baking soda and vinegar)
- Thermochemistry and Gas reactions (yeast for $O_2$ generation and exothermic reaction, baking soda and vinegar for $CO_2$ generation and endothermic reactions)
- Kinetics and Rate (bleach and blue food coloring)
- Experimental Design (temperature effects on Glow sticks)

Commercial Lab kit:

Kathy Carrigan presented her experiences of developing a hands-on lab experience in collaboration with a commercial lab kit vendor, Hands-On Labs Inc. http://www.labpaq.com/ . While at a higher cost (~$200) the custom lab kits contained all items needed including standard glassware and equipment. The commercial lab kit was non-returnable but the vendor also assumed liability of its product and has reported no safety issues with its product. A schedule of lab exercises for the GOB and introductory courses is found in the Appendix of this report. For the symposium, four sample home lab experiments using materials from the kit were presented. This represents labs from the four totally distance learning courses that Portland Community College currently offers each quarter.

1. ***Density and Measurement:*** Various measurement devices, such as a ruler, portable digital balance, and graduated cylinders, were available to measure density of various substances.

2. ***Synthesis of Fragrant Esters:*** Preparation of various esters from their appropriate carboxylic acid and alcohols. Participants carried out the procedure to mix small amounts of acids and alcohols that were gently heated in a water bath. Aromas were used to identify each one. Equipment included glass test tubes and rack and ampules of the following chemicals shown in the data table.

Table 1: Synthesis of Fragrant Esters from Alcohols and Acids

| Tube # | Alcohol | Acid | Common Name | IUPAC Name | Fragrance |
|---|---|---|---|---|---|
| 1 | Methanol | acetic | Methyl acetate | | |
| 2 | Ethanol | acetic | | | |
| 3 | Isopentyl (isoamyl) | acetic | | | |
| 4 | Methanol | butyric | | | |
| 5 | Ethanol | butyric | | | |
| 6 | Isopentyl (isoamyl) | butyric | | | |
| 7 | Methanol | salicylic | | | |

3. ***Caloric Content of Food*** (marshmallows): Participants followed the procedure to burn a marshmallow and measure the temperature rise of a water sample as shown. Equipment included a thermometer, tongs, a glass beaker, and sterno burner for initiating the combustion of the marshmallow.

Figure 1: Commercial lab kit equipment to measure the caloric content of a marshmallow.

Photo courtesy of Bernadette Harknss

4. ***Extraction of DNA*** (from strawberries): The extraction of DNA from strawberries was carried out using the equipment and chemicals provided in the lab kit. Equipment included glass beaker, test tubes, alcohol, salt, extraction solution and tongs


Fig. 2a

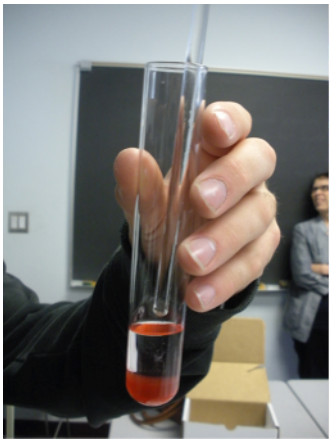
Fig. 2b


Fig. 2c

Figure 2. a) Student helper (Russell Kellogg, MiraCosta College) carrying out the DNA extraction from strawberries. b) The initial extraction mixture c) the resulting DNA extracted from the strawberries (Photos courtesy of Bernadette Harkness)

Successful Practices for Distance Learning Lab Exercises

Suggestions for success for distance learning lab experiences included:

- weekly lab assignments with generous but firm due dates (perhaps allowing one extra week at half credit),
- allowing 1 or 2 lab assignments to be dropped,
- giving videos as pre-lab lectures or setting up instructional online sessions to promote communication and answer safety questions,
- encourage collaboration among students,
- require unique lab reports that include photo or video evidence (with date stamps) of student work.

**Transitioning from On-campus to On-line: Tips for success**

For any instructor, a complete change of the mode of delivery for course content involves a large amount of preparation and work[3c]. The panel discussion, along with the presentations, gave suggestions for a successful transition from on-campus to distance learning:

1) Start early (~6-9 months) and have entire course materials prepared before start of the class. Research LMS features or software for online delivery, video technology or resources, and attend workshops to learn of new teaching/learning techniques specific to distance learning.
2) Establish support for instructor from instructional designers, distance learning support personnel, and online resources. Collaborative teaching with mentor and trainer is very beneficial. Use student beta testers for feedback and modifications.

3) Establish support for students so that they know where to seek help from distance learning support personnel and online resources.
4) Allow for extra student response time and establish clear guidelines including response times for communication between instructor-student and student-student. If using LMS tools such as discussion boards, allow for a generous time frame (2-3 days) for student postings. Use synchronous online help sessions for problem solving and immediate feedback activities.
5) Use tables to show unit cancellations for dimensional analysis solutions. For both students and instructors, word processing to show chemical solutions is sometimes difficult so use of tables simplify the process. A sample table is shown:

| Have | Factor | Want |
|---|---|---|
| 4.50 g HCl | 1 mol HCl | = mol HCl |
| | 36.46 g HCl | |

**Conclusion:**

This distance learning symposium highlighted technology and best practice suggestions used in offering online chemistry courses. Academic integrity of assessments was safeguarded through the use of various methods, including student statements of academic honesty, timed testing, creative test questions and a proctored final exam. Two different modes of delivering hands-on lab experiences were outlined in detail, one using an in-house developed lab kit and a second using a commercial lab kit developed in collaboration with a manufacturer. Both modalities had strong safety precautions embedded in the array of various lab exercises that could be performed by students in their own home. The panel discussion further outlined the distance learning aspects such as preparation, additional technology resources, support for both instructor and students, time factor differences involved in online learning and tips for student success.

**References:**

1. Examples of non-credit open courseware at four-year institutions:
a) University of Berkley Extension, http://extension.berkeley.edu/catalog/online.html (accessed June 2012)
b) MIT Open courseware http://ocw.mit.edu/courses/ (accessed June 2012)
c) Carnegie Mellon Open http://oli.cmu.edu/courses/free-open/chemistry/ (accessed June 2012)

2. Examples of distance learning chemistry courses at two-year and four-year colleges:
a) Anoka-Ramsey CC, MN http://www.anokaramsey.edu/classes/CourseSchedule.aspx (accessed June 2012)
b) Portland CC, OR http://www.pcc.edu/about/distance/ (accessed June 2012)
c) MiraCosta CC, CA http://catalog.miracosta.edu/disciplines/chemistry/ (accessed June 2012)
d) Oakton CC, IL http://www.oakton.edu/academics/distance_online_learning/index.php (accessed June 2012)
e) University of Colorado, Denver, CO http://www.ucdenver.edu/academics/CUOnline/Pages/CUOnline.aspx (accessed June 2012)

f) Penn State, PA http://www.worldcampus.psu.edu/ (accessed June 2012)
g) Millersville University, PA
http://www.millersville.edu/services/distancelearning/courses.php(accessed June 2012)

3. Distance learning in chemistry
a) Rawls, R. *Chem. Eng. News*, **1999**, *77*, 34-37.
b) Reeves, J.H.; Heath, B.P.; Casanova, R. S.; Civelli, J.L.; Kimbrough, D.R. *J. Chem. Educ.*, **2006**, *83* (3), 501
c) Smith, R.M. *A Step-by-Step Guide to Online Course Design (Jossey-Bass Guides to Online Teaching and Learning)* Jossey-Bass (a Wiley Imprint): San Francisco, CA, 2008.
d) Wang, L. *Chem. Eng. News*, **2009**, *87* (36), pp 97–99

4. Online Learning Conferences and workshops
a) Sloan consortium http://sloanconsortium.org/workshops/2012schedule (accessed June 2012)
b) The Teaching Professor http://www.teachingprofessor.com/workshops (accessed May 2012)

5. ACS position statement: Importance of Hands-On Laboratory Activities
http://www.acs.org/2YGuidelines (accessed June 2012)

6. Lockdown Browser software:
Respondus: http://www.respondus.com/products/lockdown-browser/index.shtml (accessed June 2012)

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**Appendix:** Resources and Supplemental Materials (documents and/or links):

**Documents:**

- Teaching Chemistry Online Powerpoint presentation (Lance Lund) – Attachment 1
- Distance learning for GOB chemistry: At Home Labs a "hands on" experience Powerpoint presentation (Kathy Carrigan) – Attachment 2
- Sample Lab report for Synthesis of Fragrant Esters (Kathy Carrigan) – Attachment 3
- Tentative Schedule for GOB course including list of experiments included in lab kit (Kathy Carrigan) – Attachment 4
- Tentative Schedule for Introductory course including list of experiments included in lab kit (Kathy Carrigan) – Attachment 5
- Molecular modeling - Lewis structure activity using Jmol (Lance Lund)

http://webs.anokaramsey.edu/chemistry/online/1020/models/B.htm
- List of equipment needed for In-house Lab Kit (Lance Lund) http://webs.anokaramsey.edu/chemistry/online/1020/IntroAndSafety/ItemsNeeded(Composite).pdf

**Commercial Lab kit**

- Supplied by Hands-On Labs http://www.labpaq.com/
  ***NOTE: presentation of this supplier's lab kits in this symposium does not imply endorsement by the Two Year College Chemistry Consortium or the American Chemical Society***
- ~$150-250 per kit depending on quantity and type of kit and (1 kit for all labs), non-refundable
- Contains all glassware, equipment, small quantity chemical solutions
- Vendor has $3million liability policy to insure accidents incurred by the student.
- Link to videos regarding safety, kits, educators panel discussion on use of labpaqs https://www.labpaq.com/section/educators
- custom lab kits for specific sets of lab experiments available
- Duane Cagle - contact at Hands On Labs Inc. (duane.cagle@labpaq.com)

**Hardware:** Tablet PC, or similar device, to provide worked out solutions and for supplementary online help sessions.

**Software:**
- Adobe Connect
  - web-conferencing tool that provides synchronous online help sessions
  - http://www.adobe.com/products/adobeconnect.html (education pricing available)
- Collaborate
  - web- conferencing tool that provides synchronous online help sessions
  - http://www.blackboard.com/platforms/collaborate/overview.aspx
- Camtasia Relay
  - lecture capture recorder in Mac or PC format
  - saves and sends videos in multiple formats to server (must be Windows based server)
  - unlimited time, recording tool bar can be accessed from any computer, recordings sent to a main server later
  - Can sync with Powerpoint to prompt recording
  - http://www.techsmith.com/camtasia-relay-features.html
- Camtasia Studio
  - Fully editable video recording software with voice captions and other enhancements
  - video recording with full editing features
  - Publish to many various web and mobile formats
  - Videos can be close-captioned to comply with ADA
  - http://www.techsmith.com/camtasia.asp

- MasteringChemistry – online homework system from Pearson Education
  - http://www.masteringchemistry.com
- OWL - online homework system from Cengage Publishers
  - http://www.cengage.com/owl/
- Chemsketch 12.0 Freeware
  - http://www.freechemsketch.com (free to educators and students)
  - Jmol integrated in Chemsketch for Molecular models / Lewis structure lab
  - http://www.jmol.org

Additional safety videos for distance learning
http://www.baruch.cuny.edu/tutorials/weissman/chemlab/Template.html