Challenges and Opportunities for On-Line Courses in Chemistry

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Introduction

Three national on-line chemistry courses (OLCC) have been presented under the auspices of the Committee on Computers in Chemical Education (CCCE). They have been very different in goals/objectives, format, and accomplishments. With these in mind, a group consideration of the place of on-line courses (distance education) in chemical education is timely. Below we sketch the pedagogical and technological history of the three courses offered on line, and provide the addresses of their web sites. We make a series of suggestions for the architecture and future use of on-line courses in chemistry. We invite you to question and critique our suggestions and to make suggestions of your own!

History of OLCC-1, OLCC-2, and OLCC-3

"Environmental and Industrial Chemistry," OLCC-1

"Environmental and Industrial Chemistry" (OLCC-1) was the first Internet course presented in this series: http://www.py.iup.edu/college/chemistry/chem-course/webpage.html . It involved 94 students at 20 schools during the Spring of 1996.

OLCC-1 List of Schools & Number of Students

Bryn Mawr College - PA (8)	**Pembroke State University - NC (6)**
Buffalo State College - NY (7)	**Samford University - AL (7)**
Catawba College - NC (1)	**Southwestern Oklahoma State University - OK (13)**
Concordia University at Austin - TX (2)	**University of Dallas - TX (7)**
King's University College - (Canada) (2)	**University of Miami - FL (1)**
Mississippi Valley State University - MS (1)	**University of Nebraska-Omaha - NE (2)**
Missouri Western State College - MO (5)	**University of Tennessee at Martin - TN (5)**
Montana State University - MT (5)	**University of Wisconsin-Platteville - WI (3)**
Navajo Community College - CO (1)	**Walla Walla College - WA (2)**
Niagara University - NY (4)	**York College of Pennsylvania - PA (12)**

This was a period of clear transition in the use of software and hardware in the educational environment. Schools were split between those with fully capable Internet graphics browsers and those with text only browsers. About half of the students had any notable previous experience with email listservs, and few faculty or students had any experience with web site construction and use for education. Three industrial authors wrote technical papers which were posted on the national course web site and two student papers were selected from those written during the course at the various local sites, presented on line and discussed with other on-line students. The Committee on Computers in Chemical Education indicated that, as a starting point, their goals for the on-line courses were:

1. That students should have contact with industrial chemists who wrote papers for them to read by discussing those papers with the authors
2. Students should author, and discuss with other students, a paper of their own
3. Listservs and web pages should be investigated for their use in on-line courses
4. Autonomy of the local schools should be maximized, schedules accommodated and variable credit (1-3) should be a possibility

These authors believe that the objectives for OLCC-1 were realized, albeit not in the form (nor, perhaps, to the extent) anticipated. Students indeed had contact with authors but the "discussion" took the form of mainly a single stage email question/answer exchange of text formatted papers. As one student remarked, "You don't really think I am going to make critical comment to an experienced chemist on the basis of my one week introduction to this subject area, do you?" And who, among the rest of us, would choose to do so? Discussions were lively and more engaging between students who had generated papers and other students who were reading and critiquing them. Student authored papers made practical use of "linked" references. Email message volume was extremely heavy and in a few cases overwhelming and unmanageable for some students. OLCC-1 was coordinated by Dr. James Beard, Catawba College, Salisbury, NC.

"Environmental and Industrial Chemistry", OLCC-2

"Environmental and Industrial Chemistry" (OLCC-2) was presented again during the spring semester of 1998: http://wey238ab.ch.iup.edu/olccii/index.html and this time involved 135 students from 16 schools.

OLCC-2 List of Schools & Number of Students

Cameron University - OK (5)	**Niagara University - NY (3)**
Connecticut College- CT (5)	**Simon Fraser University - BC (Canada) (24)**
Elmhurst College - IL (5)	**So. Illinois Univ.-Edwardsville - IL (18)**
Ft Lewis College - CO (8)	**Southwestern Oklahoma State - OK (22)**
Hollins College - VA (1)	**University of Tennessee-Martin -TN (11)**
Juniata College - PA (5)	**Univ. of Wisconsin-Platteville - WI (3)**
Mayville State University. - ND (3)	**Utica College of Syracuse Univ. - NY (8)**
Missouri Western State College - MO (10)	**York College of Pennsylvania - PA (3)**

The lessons from OLCC-1 were clear in mind! Students needed contact with industrial authors. Two of the original three authors returned for a second run and, in this situation, did a somewhat better job of facilitating real discussion with students, though there was still mainly question and answer! Students wrote

papers...probably too many! Available technology, and use of it by students, increased considerably. Graphics browsers were uniformly available, students generally had a working knowledge of e-mail and "surfing the web" had become a routine exercise in support of student on-line research. Conferencing software (WebBoard) was introduced for threading of messages and to reduce the amount of email volume experienced in the previous course. The two OLCC-2 WebBoard links can be examined at: http://www.chem.mwsc.edu:8080/~30 and http://www.chem.mwsc.edu:8080/~35 [note that readers of this paper can login to the WebBoard by entering as a guest]. During OLCC-2 the total number of messages was up, but easier for students to handle through the use of conferencing software technology.

A new set of goals/objectives came to the fore as a new organizing committee for the course brought new pedagogical ideas to bear on the content area. In addition to the CCCE goals (above), goals/objectives for this course included:

1. Maximization of web research and guided inquiry
2. Promotion of interaction among student participants
3. Maximization of student authoring opportunities
4. Maximization of critical analysis about issues and information gathered
5. Provision of convenient web posting mechanisms
6. Promotion of opportunities for group work

These goals were mainly accomplished through a series of increasingly more complex and engaging assignments, which began with a web search for the meaning of acronyms prevalent in environmental chemistry literature. Individual students posted the results of this initial assignment directly to the WebBoard site. Following that came a more involved web search for information on, and the writing of, brief papers by student groups about the top 50 chemicals (as listed in an article by Chemical & Engineering News during the previous year). Next came a discussion of two technical papers with their industrial authors; the writing of a second student research paper (working collaboratively in local groups) using the "EPA Industrial Notebooks" as the primary reference; and, finally, a peer review and discussion of student papers. An attempt to create more centralized facilitation of course operations fell short of what was intended by the organizers. Most participants began losing focus at the end of the semester while trying to complete the lengthy list of assignments and, as far as could be discerned by the Organizing Committee, the last two assignments were not well coordinated or executed! The quantity of assignments and the complexity of goals for OLCC-2 seemed to create a syllabus too lengthy for completion in a one term on-line course. Dr. Len Archer, Missouri Western State College, St. Joseph, MO coordinated OLCC-2.

"Pharmaceuticals, Their Discovery, Regulation and Manufacture," OLCC-3

"Pharmaceuticals, Their Discovery, Regulation and Manufacture" (OLCC-3) was presented during the Fall of 1998 (http://wey238ab.ch.iup.edu/olcciii/index.html) and involved 156 students at 16 schools.

OLCC-3 List of Schools & Number of Students

Barat College - IL (3)	**Missouri Western State College - MO (9)**
Cal Polytechnic State (53)	**Niagara University - NY (6)**
Hollins University - VA (3)	**University of Mass-Boston - MA (8)**
Humbolt State University - CA (9)	**University of Redlands - CA (7)**
Kennesaw State University - GA (10)	**Utica College of Syracuse University - NY (10)**
Lincoln University - MO (3)	**Walla Walla College - WA (4)**
Mercer University - GA (8)	**Yeshiva University - NY (3)**
Miami University - OH (16)	

	York College of Pennsylvania - PA (3)

By this time graphics browsers were well developed, many students had considerable prior experience with e-mail, web-based research, and creation of individual web sites. Conferencing software was found to be more routine. In addition to the original goals set forth by the CCCE, the course content committee which was a subset of the organizing committee for this course, hoped to:

1. Set forth a more limited workload
2. Allow students to pursue a few areas of interest and use them to collaborate with other students in group work
3. Simulate the group work that takes place in pharmaceutical houses and follow a similar process
4. Teach specific skills with specific information
5. Provide the opportunity for group authoring of a paper
6. Provide opportunities for use of both web resources and refereed literature
7. Provide convenient web posting mechanisms
8. Maximize opportunity for critical analysis of issues and information
9. Integrate the use of e-mail, web sites and conferencing software
10. Maximize the convenience of finding information so that learning of the information, rather than finding it, would consume the most time

During the third course these goals were mainly accomplished, though not to the extent (or perhaps in the form) that the authors had envisioned! The course structure and available references were more specifically identified, coupled with more effective use of prepared on-line tutorials (see tutorials on the course web page: http://wey238ab.ch.iup.edu/olcciii/skillsmap.htm). The tutorials provided external expertise not always available at all participating schools. Intercollegiate collaboration between student groups did not reach the level that could have been reached given the assignments and the telecommunications technology available. Overall course goals as envisioned by the organizers were most closely accomplished by only one local group: http://www.niagara.edu/~mgallo/315f98/315f98web/ . OLCC-3 required less extensive student writing and resulted in less centralized facilitation through more effective use of local course instructors and their individual expertise as directors of simulated "work groups." Intercollegiate work group collaboration was accomplished using WebBoard conferencing software: http://www.chem.mwsc.edu:8080/~OLCC3 . Schools appeared to rely more on the local instructors than originally anticipated, or experienced in previous courses, and resulted in the need for less outside intervention by course facilitators. This may tend to support the conclusion about the usefulness of prepared resources made available on the web. Dr. Lindy Harrison, York College of Pennsylvania, York, PA coordinated OLCC-3.

Questions for Discussion

Both praise and criticism have surfaced regarding aspects of all three courses. Keep in mind that these courses were experimental in nature and the criticism, while perhaps justified, should neither be taken personally nor allowed to obscure or even mitigate the success of these experiments.

While there are undoubtedly others, important questions to be answered are:

1. What have we learned from these experiments?
2. What should we repeat in the future of on-line chemistry courses?
3. How shall we use on-line courses?
4. What can on-line courses accomplish, that can not be accomplished by a single instructor at one location?
5. How can on-line courses be used to enrich a curriculum?
6. What changes in format or administration of on-line chemistry courses should be made?

Conclusions by The Authors About The Questions Indicated Above

What have we learned from these experiments?

The authors suggest that college chemistry faculty have learned a great deal from these courses. Among the learning related to goals for the courses:

1. Courses should be sufficiently modular that local schools can use pieces to supplement other courses and can delete modules that occur during their vacation times.
2. Courses on line should be short enough that most semesters will be in session a week before the start of the on-line course and a week following the conclusion of the on-line course.
3. Discussions of papers, with their expert authors, must be carefully facilitated by an experienced facilitator or the discussion will potentially become a question/answer session. An industrial author can not be expected to be an excellent facilitator.
4. Discussions should be limited in the number of participants, possibly with the supportive help of the group at each site. Experience in the first course showed that a question and answer from each student was not easily managed in classes approaching 100 students.
5. Course objectives should be listed at the beginning of the course for both the students and the instructors to see.
6. An on-line test should be available for the course, if possible.
7. A definite protocol for posting of materials during the course should be determined at the beginning and rigidly required of all sites. These procedures need to be provided ahead of time to participating faculty in order for them to direct the effort at the local level. This may well vary from one course to another. Additional posting at local sites can be allowed.
8. Copyright considerations should be outlined to the local instructors and rules set forth to the students during the on-line course.
9. Web sites should provide a convenient access to the on-line course content, a place to post student work and a section showing a summary of the evaluations for the course.
10. Opinions vary about whether faculty should be allowed to participate in student discussions with the "experts." Some believe these should become student and faculty discussions, while others view this as a possible source of disruption in the learning process.

What should we repeat in the future of on-line chemistry courses?

1. All courses should be repeated at least twice. Few college courses are best presented in the first presentation.
2. The use of web sites, e-mail listservs and conferencing software seems to have taken the following pattern: the web site is best used for permanent parts of the course (i.e. syllabus, links, etc.); conferencing software is best used for the threading of dialogue pertaining to parts of the course (i.e. interactive discussions, posting of assignments, etc.) and for chat sessions; and e-mail listservs are best used for delivery of administrative messages (i.e. weekly schedules, faculty-to-faculty concerns, etc.). Separate faculty and student listservs were employed and worked well in all three courses.
3. The previously used time lines and preservation of local course autonomy seem to have worked well and should be repeated.
4. Grading should continue to be at the local level.

How shall we use on-line courses?

1. Stand-alone specifically titled full courses with fixed credit hours are a primary option.
2. Modular courses with variable credit and provisions for the local option of participation amount is a secondary possibility.
3. Modular courses designed as information supplements for a standard local course is a third option. This could include segments of courses of the type so far offered, as well, as segments such as the use of new instrumental techniques or prepared tutorials on the use of particular instruments not available at a particular campus. Consortium sharing of instruments could be feasible within this

framework. Thus students from campuses A and B could use a computer-controlled instrument housed at campus C. Students at campus C could accept a sample from campus A or campus B, and record information on that sample and then could actually run the sample using their instrument. Students at campuses A and B could then manipulate the data using on-line available software.

What can on-line courses accomplish, that can not be accomplished by a single instructor at one location?

1. The most obvious benefit of on-line courses is the sharing of collective expertise (i.e. on-line tutorials) by local faculty participants for applications to coursework not currently existing on a local campus. On-line courses and their segments involving subject experts and other remote faculty provide expertise additional to that available on campus.
2. Critical analysis and discussions of subject material both on and off campus will be only as good as the facilitators that coordinate them. Technology can only deliver the content produced by the facilitators.
3. Finding references and linking to animations, simulations and the like provides collaborative support to local instructors which minimizes web-searching time and increases course information for all participants.

How can on-line courses be used to enrich a curriculum?

1. They can be used as stand-alone courses.
2. They can be used as modular supplements.
3. They can be used to enhance course content
4. They can be used to enhance course resources such as instruments.
5. They can be used to enhance student writing, collaboration and research skills.

What changes in format or administration of on-line chemistry courses should be made?

1. Some changes in format are expected with the evolution of technology (i.e. on-line streaming video).
2. The two currently available courses should be offered another time, and during that time, other items of this list should be set into operation.
3. A committee operating under the CCCE should be appointed to administer these courses and be empowered to set course philosophies and to make all relevant decisions. They should be charged, at the outset, with obtaining operational funding for the reduction in load of individuals who complete successful proposals for courses and the related technology costs. Course proposals should be of one-two pages, outline specific proposed course objectives, provide planning details of the course and use of the web site and other technologies.
4. A list of courses and dates for the next 2-4 years should be developed and made available among the listing of courses in ACS literature distributed to all chemists.
5. Course planning requires a minimum of one year of development time, and will result in a longer-term commitment by local participants than is the standard practice at many institutions. Recruitment of a development committee must also take this into account.
6. Reduced load salary reimbursement should be available to institutions and individuals that are willing to develop and facilitate a course. Compensation to expert authors may be included in this recommendation as an incentive to encourage industrial expert participation.
7. A committee of technology-capable individuals should be identified and recruited to serve as references to train individuals who are assembling courses. A "short-course" in techniques and philosophies for distance education could be included among ACS short courses.
8. A set of guidelines for the preparation of a web site should be made available to potential course organizers. These items should be viewed as guidelines and not as mandatory requirements.

Invitation to ConfChem Participants to Critique Above Suggestions and to Provide Other Suggestions

We, the authors, have proposed questions to be considered and, within those questions, items for consideration. We have also given our perspectives to these questions. We now invite you, as participants in this ConfChem (to visit the course web sites if you were not a course participant) and to make suggestions for and about future on-line courses. We invite you to contribute to the discussion for each of the important questions and, as well, to suggest additional important questions. We, the authors, will take notes and attempt to summarize these comments in our future discussions with the CCCE. Having some extended experience in this arena, you can see that, with this paper, we are attempting to step outside the normally established limits of singly presented papers at meetings or on-line textual papers, to bring a new dimension to ConfChem papers. This is an experiment for us in presenting an interactive paper, just as the on-line courses (for which we chaired Organizing Committees) were an experiment in the realm of distance education. We look forward to your comments and are hopeful that the resultant discussions help to clarify the directions that need to be taken in future efforts by those involved.