Introduction:

OLCCs are OnLine Chemistry Courses that have been organized by the Committee on Computers in Chemical Education (CCCE) of the ACS Division of Chemical Education Committee (CHED). The CCCE is a standing committee of CHED, which in addition to hosting OLCCs runs the Online ConfChem conferences, an online Newsletter, and whose volunteer members organize regional and national symposia and workshops related to the use of computers in chemical education. Through OLCCs the CCCE enables faculty in schools to offer their students courses they may not normally be able to offer, and this is done by bringing into the classroom online experts from both academic and non-academic institutions. The first OLCC was run in 1996 and this paper will describe the history of OLCCs over the past twenty years, the current Cheminformatics OLCC and their potential role in future education.

The acronym OLCC is actually a misnomer dating to the early days of the World Wide Web, and today we would classify OLCCs as a form of hybrid class involving collaborative teaching and learning where online guest lecturers interact with students and resident faculty facilitators distributed over multiple schools. The OLCC curriculum model represents an extension of the online ConfChem conference model to include students in the discussion of material posted online. The first ConfChem was offered in the summer of 1993 [1,2], where papers were posted online and discussed over an email list, and a review of ConfChem can be found in the 2013 CCCE Newsletter article, “The Twentieth Anniversary of ConfChem Online Conferences: Past, Present and Future” [3]. That is, in a ConfChem conference a paper is posted online and discussed with faculty through an email list, while in an OLCC there were two lists [4], one for faculty and one for students, and through the student list students from multiple campuses could interact with experts who had posted material online.

OLCC Terminology

As multiple schools can offer a class in an OLCC course which involves both residential and online faculty we need to define some terminology in the context of an OLCC.

Lecturer: Subject Domain Expert who functions as an online guest lecturer and interacts with students from multiple campuses. This person does not “lecture” to a given class, but posts material online and interacts with students from multiple classes. The lecturer also interacts with faculty from multiple schools as they collaboratively develop curriculum material, which often results in faculty gaining new skills and competencies. Lecturers do not grade any student assignments and may be from both academic and nonacademic institutions.

Facilitator: The instructor of record, is a teaching faculty member in a school offering the OLCC. The facilitator meets with students in a normal classroom, is responsible for all assignments and student grades. The facilitator interacts with both lecturers and facilitators from other schools. The facilitator need not be an expert in the course subject matter and many facilitators use the OLCC as an opportunity to develop new skills. The OLCC class may be part of a facilitators normal teaching load, or overload, if only one or two students take the course as an independent study or undergraduate research class.
**Course:** The OLCC course is the core course material being presented online to all schools. The OLCC course defines the core curriculum content of the material presented, and the schedule the online guest lectures are available to interact with students from multiple schools.

**Class:** Each school has a unique class of students who are taking the course for credit at a specific school. Typical classes range from 1 to 3 credit hours and each school has a unique syllabus that is created by the facilitator of that school, and the class syllabus follows the course schedule with regards to availability of online guest lecturers.

**Web 1.0: The Early OLCCs**

All of the early OLCCs (web 1.0; 1996-2004) involved authors posting papers online and students discussing the papers and related assignments with authors through email lists. The material for the first 4 OLCCs is no longer available online, but the sites for OLCC 1-3 were archived by the WayBack Machine of the Internet Archive[5]. All the material for OLCC 4 was behind a log-in page, and so not captured by the WayBack Machine. The material for OLCC 5 from the Fall of 2004 is still available at the original course site[SCOTT VB]. Of notable interest is that as you read through the early OLCCs you can see how the growth of the WEB was influencing the nature of the courses.

**OLCC 1: Spring 1996 - Environmental and Industrial Chemistry**

Work on the first OLCC started in January of 1995[6], with a trial run occurring in the fall of 95[7], which was concurrent with the second ConfChem (ChemConf 95)[8], which was pre-HTML and had text-file papers posted online. The first OLCC was HTML based and this actually occurred before the first ConfChem to use HTML. In fact the third ConfChem, which occurred after OLCC 1, had instructions on the use of Netscape Navigator[ChemConf 96][9]. The course was offered to 104 students at 22 schools[10], many of which did not have graphics capable internet browser and only around half the students had experience with email listservs[11].

In the first ConfChem 2 weeks were devoted to each paper and figure 1 is a screen capture of the site which was archived in the WayBack machine of the internet archive. During the class a total of 5 papers were discussed, three presented by guest lecturers and two of which were selected from student submissions. After the course an information and evaluation form was sent to the students and the results from 49 of 98 students from 17 of 21 schools were published in the Spring 1997 CCCE Newsletter.[10] Of interest is that the majority of survey Reponses to “What liked Best About the Course” dealt with the papers themselves and only 4 of 47 gave reference to the World Wide Web as an information resource. Even the web link to “WWW sites referenced on this page” was not a page of resources, but a link to Yahoo (which itself was incorporated in March of 1995). None-the-less, an analysis of several of the student paper’s citations did show that they were using the web for a resource.
Welcome to the On-line Chemistry Course Home Page

*Featuring: Environmental and Industrial Chemistry*

*Dates of On-Line Segment: February 5 to April 19, 1996* (last updated June 1, 1996)

*Course Description:*

A study of the relationships between industrial chemistry and environmental chemistry as they affect one another in the operation of chemical facilities in a global society. This will be an intercollegiate course involving electronic dialogue with students, teachers, and experts from both industry and academe. The on-line computer character of this course provides an unprecedented opportunity for sharing a wide variety of viewpoints and for applying chemical knowledge to important current problems.

In this course the Internet will be used for discussion between the authors of papers and students, and for discussion between students at different schools. The ten-week class (eleven weeks minus one for Spring Break) will be divided into two-week segments. In each segment a paper or papers will be discussed by the students on a student discussion list. The students will have an opportunity to ask questions of the authors. Some of the papers will be authored by experts in the field and others will be presented by students.

It is intended that there be an evaluation mechanism in place, but it would be the responsibility of each local faculty member to assign grades for the individual students. In addition to the student listeners there will be a faculty listeners to allow free communication among the various faculty members involved, as well as, between faculty and authors of papers.

A trial run for OLCC was held Fall 1995. [Click Here](http://dirac.py.iup.edu/college/chemistry/chem-course/webpage.html) to see the results of that trial.

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**Course Content**

<table>
<thead>
<tr>
<th>Information for faculty</th>
<th>Participating Schools</th>
<th>Helpful Hints - The discussion so far</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert papers</td>
<td>Student Papers</td>
<td>schedule</td>
</tr>
<tr>
<td>WWW sites referenced on this page</td>
<td>OLCC Computer Facilities</td>
<td>typical scenario</td>
</tr>
</tbody>
</table>

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**Meet The Experts**

Stanley S. Seelig, FAIC, Seelig and Assoc., Inc.

Dr. John N. Armor, Air Products and Chemicals, Inc.

Dr. Michael Truby, Monsanto Co.

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Any additional Questions can be forwarded to the [Organizing committee](http://dirac.py.iup.edu/college/chemistry/chem-course/webpage.html).

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***Computer services for the OLCC listeners have been donated by Clarkson University

For questions concerning this web page contact George Long, Ph.D. (glelong@grove.iup.edu)

Facilities for this web page provided by Indiana University of Pennsylvania College of Natural Science and Math Weyandt Hall Indiana, Pennsylvania 15705

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*Fig. 1 OLCC 1 Screen Capture from the Way Back Machine of the Internet Archive*
OLCC 2: Spring 1998 OLCC – Environmental and Industrial Chemistry

In the two years between the first two OLCCs the internet had sufficiently matured so that all students had access to graphics capable browsers by the time the second OLCC took place, and the website showed far more use of the World Wide Web. In addition, WebBoard conferencing software was used to thread email comments[11], and assignments included extensive web-searching with “chemistry behind pollution prevention” being chosen as an underlying theme for the course[12]. One of the challenges of contemporary OLCCs became very clear during the second OLCC, in that too much material was attempted to be covered in a single semester, with the result that students started “losing focus” near the end of the semester[11].

Fig. 2 Screen Capture from Way Back Machine

OLCC 3: Fall 1998 – Pharmaceuticals, Their Discovery, Regulation and Manufacture

A third OLCC was run in the Fall of 1998 and offered to 156 students at 16 schools. Once again lists and WebBoard were used to facilitate discussions. This course included online tutorials and required less writing than the others, with the results that students appeared to rely more on local instructors than anticipated[8-D]. Topics covered included computer assisted drug discovery, case studies and a coverage of the FDA approval and testing process[13].

Fig. 3 Screen Capture from the WayBack Machine of the Internet Archive
OLCC 4: Spring 2000 – Environmental and Industrial Chemistry

Nine schools and 65 students participated[14] and the entire course site was run on WebBoard, which means the WayBack Machine of the Internet Archive could not capture the content the way it captured the content for OLCCs 1-3.


OLCC V is the only one of the early OLCCs for which the actual website is still active. The Fall 2002 ConfChem[16] was on “Teaching Safety in High Schools, Colleges and Universities”, and at the end a discussion ensued with respects to organizing an online course for undergraduates[17]. An organizing committee was formed to create the OLCC and both the ACS Divisions of Chemical Education (CHED) and Division of Chemical Health and Safety (CHAS) agreed to sponsor this OLCC, making it the first ACS interdivisional OLCC. This course was run like a Confchem conference where each week a new author presented material that was discussed over an email list.

Figure 4. Screen capture of OLCC 5 showing assignments for three weeks.

The course material is available online in the course content section of the website and in addition to weekly presentations authored by experts there were assignments from the National Academy of Sciences 1995 Prudent Practices in the Laboratory: Handling and Disposal of Chemicals[18] (which has been superseded by the 2011 edition)[19] and the 2003 edition of “Safety in the Academic Chemistry Laboratories, 7th Edition, Vol 1[20], both of which were freely available to students. The course was
offered in 8 schools, including the University of Arkansas at Little Rock (UALR), where the author of this paper was a facilitator. At that time UALR did not have a chemical hygiene plan (CHP) or officer (CHO), and students used this as an opportunity to create SOPs (Safe Operating Procedures) for activities in their research labs, and to create CHPs that were vetted by expert lecturers.

**Web 2.0: Current OLCCs**

OLCCs were effectively the extension of the ConfChem online conference to include students in discussions, and current OLCCs use a modification of the current Confchem system. Two major problems plagued the old web 1.0 Confchems and OLCCs. First, the CCCE did not host the papers, many of which were posted by the actual authors and have now become lost, (like OLCCs 1-4). Second, was the threading of the discussions, which was done in either a list archive, or in WebBoard. With support from the Chemical Education Library a decision was made to move ConfChem to the Drupal web 2.0 PHP/MySQL based content management system[21], which would allow the CCCE to archive the papers and thread the discussion below them as comments. The first Confchem Web 2.0 conference was run in 2010 on a Drupal 6 site[22], and then in 2014 the site was upgraded to the current Drupal 7.[23]

A Drupal content type creates a web page with specific features, like a blog or a wiki, and two new content types were created for ConfChem, the “ConfChem Conference” (conference homepage) and “ConfChem Article”, (conference paper). The “conference” homepage actually pulled material from the articles, like the title, authors, dates and abstracts, while the article showed the actual paper and allowed discussions by connecting comments to an email. In an OLCC, we wanted to be able to discuss an article at multiple levels, and so introduced a third Drupal content type, the TLO (Teaching and Learning Object), which allowed discussion of an object within a predefined section of text within a page. This is shown in figure 5, and in an OLCC the “conference” becomes the course, showing the chapters and learning objectives in contrast to titles and abstracts, while the article became the OLCC Module (or chapter).

![Diagram](image)

**Figure 5.** Outline of how the Drupal ConfChem content types were modified and extended to create the OLCC content types.
The TLO was actually created so we could embed a learning object into a page, like a graph, Java applet or video, and discuss the object. But it was quickly realized that you could embed a TLO without any object into a page, and enable discussion of the paper at multiple levels. This is demonstrated in figure 6, where instead of only being able to discuss the entire chapter on Public Compound Databases (like in a ConfChem article), you can discuss section 1.1 on PubChem independent of section 1.2 on ChemSpider.

Figure 6: The first part of module 6, http://olcc.ccce.divched.org/2015OLCCModule6P1 covers chemical databases and there are 10 embedded TLOs, one for each database. The image shows the sections for PubChem and ChemSpider, and this model allows multiple discussions to occur in a single chapter.

What is the TLO? The TLO actually has 4 fields, with the title, caption and body being embedded into another page, but the body not being embedded, and only viewable if you click on the TLO title. A Youtube video describing the TLO content type can be found here, https://youtu.be/-k6QvCTTa9M.

If you look at section 2.5.1 of the Fall 2015 Cheminformatics OLCC course, Two-dimensional similarity methods of module 6, http://olcc.ccce.divched.org/2015OLCCModule6P1#2.4 you will see the embedded fields as illustrated in figure 7.
Fig. 7 Showing a TLO embedded into a page, the “Title” of the TLO is linked to the TLO which shows the above 3 field, plus additional content within the body of the TLO and any comments made on the TLO. If you click “make a comment”, you contribute to a discussion that is threaded below the body of the TLO (and trigger an email to anyone subscribed to the TLO).

The result of this work is that students can discuss a section of a paper, instead of the whole paper.

**OLCC 6: Fall 2015 – Cheminformatics OLCC**

Before giving a description of the 6th OLCC, a brief description of why an OLCC on cheminformatics is warranted, and this needs to be placed into the broader context of an NSF TUES grant that supported this work. Microsoft Research’s book, “The Fourth Paradigm: Data Intensive Scientific Discovery,” [24] describes 4 paradigms of science:

1. Experimental Science (Thousands of Years Old)
2. Theoretical Science (Hundreds of Years Old)
3. Computational Science (Decades Old)
4. Data-Intensive Science (Its New!)

Cheminformatics is a very broad science covering a wide range of topics, and we sought to seek those skills that would be of most value to graduating undergraduates. The typical undergraduate curriculum does not mention modern IUPAC nomenclature like InChI, or how to handle online data from non-
webpage interfaces. In fact, research programs like Project Tomorrow, which have survey results on digital technologies from 4.5 million people since 2003, show a frustration of the youth with the use of technology in school, as indicated in this 2013 report:

Year after year, students in our focus groups remind us that their dissatisfaction with using technology at their school is not about the quantity or quality of the equipment or resources; it is about the unsophisticated use of those tools by their teachers, which they believe is holding back their learning potential. The comparison of the students’ perspectives on obstacles to technology use at school from 2003 to 2012 reflects this new reality which some are calling the second level digital divide.\[25\]

Cheminformatics is clearly on the cutting edge of the use of digital technology in the chemical sciences and yet few schools are prepared to offer a course in cheminformatics, which in the context of the Fourth Paradigm and the second level digital divide, make it an ideal topic for the CCCE to run an OLCC on.

So, after over a decade of inactivity, the CCCE ran the 6th ConfChem in the Fall of 2015 on Cheminformatics.\[26\] This was a joint effort between the ACS CHED CCCE, the ACS Division of Chemical Information (CINF) and a variety of other organizations, including the NIH NLM NCBI PubChem and the IUPAC affiliated InChI Trust. Four Universities with around 45 students were involved with this OLCC, which followed a schedule similar to the 2004 OLCC, in that each week a new online module presented material and the authors interacted with students, but discussions could occur at both the paper (module) or the TLO level.

![Figure 8: Fall 2015 Cheminformatics OLCC Homepage](image-url)
During the summer of 2016 all the curriculum material from the Cheminformatics OLCC was archived within the LibreText (formerly ChemWiki) HyperLibrary, and all this material is now available to other classes that use the HyperLibrary, http://chem.libretexts.org/.

Figure 9: Integration of Fall 2015 Cheminformatics OLCC material into the LibreText HyperLibrary

OLCC Projects – Another objective of the OLCC was to create student projects and web site features were developed to enable collaborative projects across multiple campuses. Figure 10 shows the website features created to enable online intercollegiate collaboration.

Figure 10: Features of web site that enabled online intercollegiate collaborative projects.
One of the facilitators (Stuart Chalk, UNF) received an interdivisional ACS CHED/CINF Innovative Projects Grant to support student travel to the spring 251st ACS National Meeting in San Diego where students presented projects developed during the Cheminformatics OLCC. During the two sessions 18 oral papers were presented with 11 being by students.

![Image](image1.png)

Figure 11: Student and Faculty members got to meet in person during a special CHED symposium at the Spring 2016 ACS National Meeting in San Diego.

**The Future**

One of the ideas behind having an OLCC on Cheminformatics was that cheminformatics is changing the fundamental cognitive artifacts used to represent, manipulate and communicate chemical information, and expert’s ability to implement new artifacts in their work flow may be impeded by prior knowledge based on the existence of new artifacts[27]. This led to the idea of could we discover new ways to use cheminformatics resources during the course, and if so, could we embed them into the course text? This lead to the development of an extensible Course Management system, which can be viewed as an extensible educational ontological framework based on the concept of a partonomy created through the process of embedding Teaching and Learning Objects (TLOs) within TLOs. The beauty of this is that how the ontology grows is a direct consequence of student interaction with, and extension of, the course content.
OLCC 7: Spring 2017 – Cheminformatics OLCC: An Introduction to the World of Chemical Data

The second offering of the Cheminformatics OLCC is building on the experience of the first offering. The course is designed to be offered as either a 1, 2 or 3 credit hour class, and it is not too late to join if you have a student or two who would like to take it as undergraduate research or independent study. Programming is not a prerequisite, although there will be opportunities for programmatic access to online databases through familiar technologies like spreadsheets.

The course will have 4 major facets to it. The first series of 3 modules will be an introduction to how chemicals, and chemical data are represented on computer. The second will involve 5 modules dealing with public compound databases, and there will be an emphasis on PubChem. Students and facilitators will have the opportunity to interact with NIH staff scientists during this module, and many of the activities will involve students making screen capture videos of their work, like these videos from the Fall 2015 course, http://olcc.ccce.divched.org/2015OLCCModule6P1TLO-2-1. Throughout the course the students will also have the opportunity to work with a suite of tools for programmatic access to online
data, although there will be leeway for individual student aptitude with programming, who will have the opportunity to work with Python and R, but all students will be able to pull material from databases with programs like Microsoft Excel and Google Sheets. The final part of the course will be devoted to student projects, and there are faculty mentors who are literally from around the world who are willing to collaborate with students on these projects. For further information contact Bob Belford, rebelford@ualr.edu.

Social Annotation Technologies – The CCCE has also been exploring several social annotation technologies, specifically, Lacuna Stories[28,29], that was developed by the Poetic Media Laboratory at Stanford, and Hypothes.is[30], both of which have extensive educational support. Currently, discussions are made at the OLCC article, or TLO level, which is based on the comment feature of these Drupal content types. With annotations, discussion can not only be extended to spontaneous topics, but the discussions can generate navigational pathways through the course material and engage students in manners appropriate to digital text. The advantage with Lacuna Stories is that it is built on Drupal, has many tested features, and we already have it installed and are testing around with it. The advantage of Hypothes.is, is that the annotation functionality is extensible to any page on the web, which opens huge opportunities. Frankly, these are both really exciting options and over the next several weeks a decision will need to be made as to which one we should try, but there is a clear opportunity to pioneer the use social annotation technologies in the upcoming Cheminformatics OLCC.

Acknowledgements – The 2015 and 2017 OLCCs were run on a Drupal based website that was designed with the help of Jon Holmes of the University of Wisconsin – Madison, who also maintains them, and the ConfChem website. This work was also supported by the 2012 ACS Innovative Projects Grant, “ConfChem Folksonomy Indexed Archive”, and NSF TUES grant #1150485, “Cheminformatics OLCC”.

References


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