

Program Overview and Assessment Methodology for Online Instruction in Chemistry at Oregon State University

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Abstract

Oregon State University offers a wide range of online chemistry courses. The courses are well subscribed, as of 2013 approximately 13% of our department's student credit hours were awarded in online courses, and both the online enrollment totals and the fraction of effort devoted to online instruction continue to increase. In this article, we describe the program history, provide detailed course offering descriptions, indicate student populations and our program-level assessment plan in the program. Program and course level assessment methodologies include collecting and evaluating both instructor and student feedback, adding learning analytics to course content for chapter and lab-level assessment data, and comparison of formal course outcomes.

Keywords: online education, chemistry, distance, Oregon State University

Teaching chemistry online? How is that possible? Through [Oregon State University Ecampus](#), growing numbers of students are finding that studying chemistry online is not only possible, but is a rigorous and convenient way to meet the requirements of their academic program. This article will address potential concerns about online chemistry education, the approach the OSU Department of Chemistry takes to assess our program and ensure quality, and how OSU Ecampus helps students around the world meet the challenges of their academic programs.

History of OSU's online program

During the 2012/2013 academic year (starting summer term 2012), students took more than 8,700 credit hours of chemistry online from Oregon State University. This compares to 59,000 student credit hours of on-campus chemistry, representing 12.8% of our overall program. Figure 1 shows the growth in both the on campus and online components of the OSU chemistry program over the past dozen years.

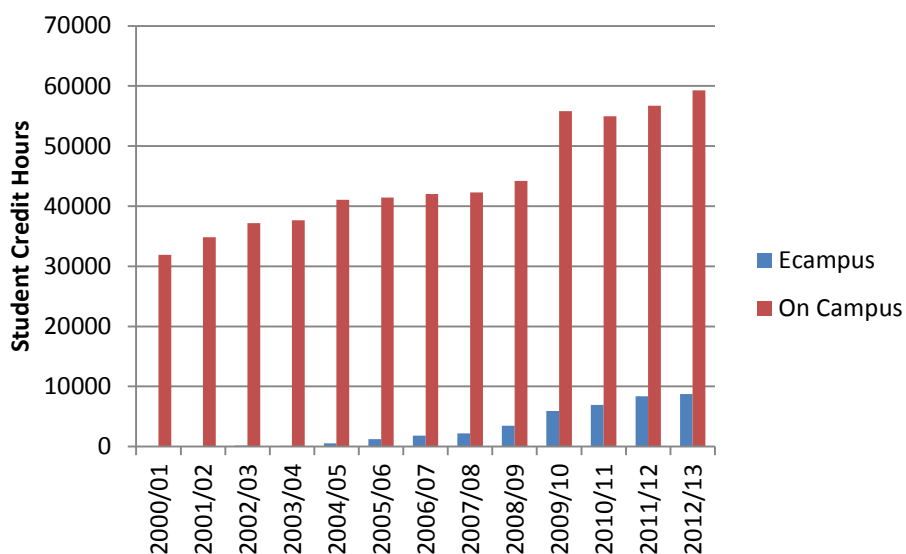


Figure 1. Student credit hours (SCH) in online and on campus chemistry at OSU for academic year since 2000/01.

Oregon State University's online chemistry program started in 2001, with Dr. Richard Nafshun teaching the first section of General Chemistry. This class had four students who worked with Dr.

Nafshun to acquire a fundamental understanding of chemical reactions and scientific measurements, and become familiar with the principles, laws, and equations governing our understanding of chemical combination. Using video modules, online homework problems, and email access to the instructor, the students learned chemistry, and as word spread the program grew. In the first few years, the program utilized a popular commercial laboratory simulation product, but a review of the program indicated both instructor and student dissatisfaction with this laboratory platform and the learning outcomes achieved. Since then, OSU has exclusively used OnlineChemLabs, a spin-off business developed by three OSU faculty members. Both students and instructors have seen a dramatic improvement in outcomes, as will be noted below.

Who are these students? OSU's online instructors have students from all over the world, including students in the military stationed in Afghanistan and Iraq. The students include people who are:

- employed and want to complete their degrees
- seeking an additional certification, such as applicants to RN-to-BSN programs
- applying to medical or dental school but did not complete the chemistry requirements as a part of their undergraduate education
- spouses of military personnel
- stay-at-home parents
- high school students needing a greater challenge than what is offered at their high school
- traditional college students attending another institution who want to complete chemistry on their own schedule, or were not able to get in to the class at their institution
- on-campus students at Oregon State University who want the flexibility of online learning or want to continue their studies during the summer break
- degree-seeking students in the Oregon State Ecampus program who need chemistry as a part of their degree studies

Each student comes to the program with distinct needs; OSU strives to offer a variety of class levels and delivery modes that fulfill the requirements of so many students.

Program overview

During most terms (including summer), OSU offers eight to 10 online classes, including two levels of General Chemistry and the complete Organic Chemistry sequence. Currently available Ecampus classes include:

- CH 121/122/123 *General Chemistry* (for non-majors)
- CH 231/232/233 *General Chemistry* (for science majors)

- CH 261/262/263 on-campus labs for the 200 series General Chemistry
- CH 130 *General Chemistry of Living Systems*
- CH 140 *General, Organic, and Biological Chemistry*
- CH 331/332/337 *Organic Chemistry* (includes on-campus labs)
- CH 374 *Technology, Energy, and Risk*
- CH 390 *Environmental Chemistry*
- CH 411/412 *Inorganic Chemistry*
- CH 490/590 *Computer Programing for Scientists*
- CH 584 *Instruments and Online Interactions in the Sciences*

This section will focus on classes of special interest to students in the health professions, moving from most basic to most advanced classes needed by these students.

In some allied health fields, students are simply required to have “one chemistry class”. OSU offers these students several options, depending on their interests. They may take one term of General Chemistry (CH 121 or CH 231), or they may choose one of our classes developed especially for those who need a basic understanding of the chemistry of life. These classes — CH 130 and CH 140 — are similar in topics covered, with one major difference: CH 140 goes further into depth on general chemistry and is worth 6 quarter credits. The additional credits (CH 130 is worth 4 quarter credits) mean that a student at an institution that uses semesters can transfer CH 140 as 4 semester credits, meeting the requirement of “one semester of chemistry.” Both these classes include online labs.

Moving on, students in some health professions require “one year of General Chemistry with labs.” Again, Oregon State offers options, depending on whether the institution requires *majors*-level chemistry. General Chemistry for non-majors, CH 121/122/123, is offered both online and on-campus at OSU, and is taught by some of the same instructors in both formats. This series gives students a broad understanding of chemistry and readies them for more advanced classes in their field of study. As mentioned earlier, the labs are completed in an online format; interested parties can see a demonstration of how online labs work at www.onlinechemlabs.com. At this level of chemistry, learning objectives for the labs include fundamental aspects of the scientific method and research methodologies such as: evaluating the impact of measurement error on data collection and interpretation, how modern instruments are used in chemical characterization and discovery, how to design and use experimental controls and replicates, and more. In addition, online students can explore scientific instrumentation not normally available to undergraduate students, such as

nuclear magnetic resonance (NMR) and neutron activation analysis (NAA). OSU instructors have found that the course learning objectives are being well met using the online format.

If a student requires “one year of General Chemistry for majors,” they will take the CH 231/232/233 and CH 261/262/263 sequences. These classes cover the same topics as the other General Chemistry series, but go into further depth. The two 200-level series can be taken separately, and the lab series (CH 261/262/263) can be skipped if the student does not need labs. The lecture classes, worth 4 quarter credits each, are offered completely online through Ecampus. The labs are on-campus but are formatted to be convenient for distance students. Each class in the CH 261/262/263 series is offered twice per year: once during the academic year over a three-day weekend, and once in the summer in a nine-day sequence (so students can complete the full series with one visit to Corvallis). During their visit to campus, students spend full days in the lab; their lab reports are written and submitted later from their home. During the 2012/2013 academic year (including the previous summer), 36 students completed their lab requirements this way.

Either of the OSU General Chemistry sequences can be used as prerequisites for the Organic Chemistry sequence. (The 200-level students must also complete the labs.) This sequence is also offered on campus, taught by the same instructors, and is taken by non-chemistry majors. Many students mention that they are taking organic chemistry in OSU’s program to prepare for application to medical school.

The first two classes in the sequence, CH 331 and CH 332, are taught fully online. The third class, CH 337, is a hybrid class, with a format of two weeks of online work, two weeks in Corvallis for labs, then two more weeks of online work. This hybrid class is offered every summer; this summer 20 students will come to Corvallis to study and enjoy OSU’s beautiful campus.

Assessment

So — how does an online experience compare to our traditional learning models? OSU works hard to ensure that students in online classes meet the same learning objectives, and are evaluated using the same criteria, as on-campus students. Students who register for an online class expecting it to be “easier” are sometimes shocked to find out how hard they have to work to obtain an acceptable grade. Rigor and expectations are high, and serious students appreciate this.

Outcomes and course performance are assessed from four different perspectives:

1. Instructor and student feedback
2. Student surveys
3. Learning analytics
4. Formal outcomes

Anecdotal evidence from instructors and students offers the most immediate feedback. As mentioned earlier, OSU's online classes are taught by instructors who also teach on campus, and they have the same expectations of their online students as their Corvallis students. According to one current instructor:

I've found that our Ecampus students do remarkably well with the course materials. Having the variety of material available for students that we do, students can find what works best for them, and review it as much as they need to understand the concepts we're covering. We also have the advantage of great TAs, who work well with our instructors to create a positive and responsive learning environment that students can thrive in. I've seen some incredibly perceptive questions coming from our Ecampus students that show a strong understanding of the subject, and I'm comfortable saying that our Ecampus students are getting just as good of a mastery of the course material as their on-campus counterparts.

Much of the student feedback (item #2) comes from targeted online surveys conducted at the end of each term. For the last five terms, OSU has been surveying students (both online and on-campus) about their chemistry *laboratory* experiences. These satisfaction surveys asked the following questions, rated on a five-point Likert scale:

1. This course helped me to understand fundamental concepts and theories in chemistry.
2. This course provided historical perspectives on major theories and ideas.
3. This course demonstrated connections with other subject areas.
4. This course examined the nature, value, and limitations of scientific methods.
5. The lab experiments in this course helped me to develop a deeper understanding of fundamental chemistry concepts.
6. The lab experiments in this course helped show how experiments can be used to learn about the world.
7. The lab experiments in this course allowed me to practice the use of data analysis techniques.
8. The lab experiments in this course demonstrated how modern instrumentation can be used in chemical research.

Demographic data and student comments were also collected. Using weighted totals for all eight questions (*Strongly Agree* received 4 points, *Agree* received 3 points, etc.), it was determined that students consistently rated the experience with online labs as high, or as much as 14% higher, than the on-campus experience (see Figure 2). Students appreciated the ability to work at their own pace to develop comprehension, and felt that the labs added to their overall experience.

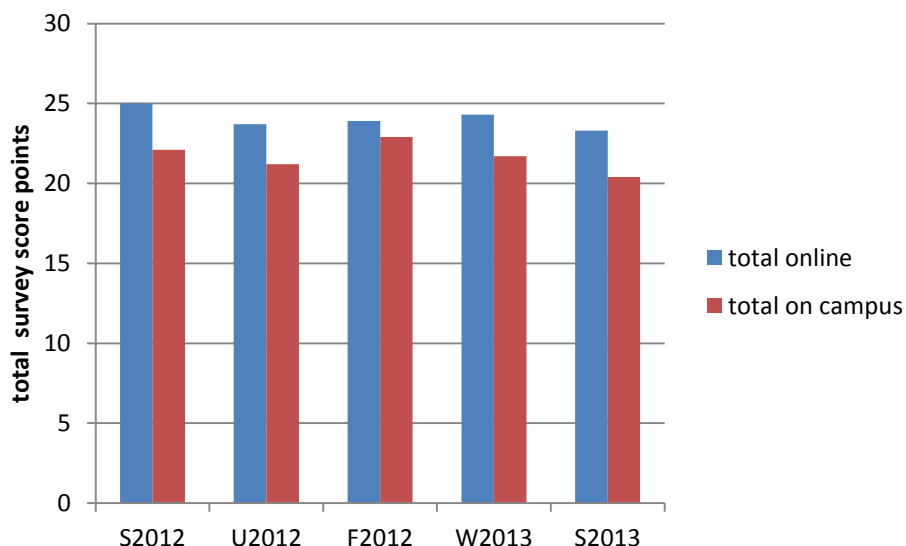


Figure 2. Student satisfaction with laboratory instruction for online and on campus based delivery using survey response totals.

The third component of the assessment program utilizes pre- and post-quizzes at the chapter level. These quizzes are integrated into a cyber-enabled tool called the Concept Warehouse, developed by Chemical Engineering collaborators from across the United States interested in facilitating concept based instruction and assessment (for more information, see <http://cw.edudiv.org>). The quizzes used at OSU are being continuously developed to assess student learning of specific chemistry concepts; concept questions are being created and evaluated for other fields of study as well. All students take the pre-quiz before beginning to study a chapter, and then take a second quiz with similar questions after completing the chapter. The Institutional Review Board (IRB) has approved this research. Therefore, only the data collected from students that give informed consent electronically is analyzed to determine quality of the questions, improvement in student

comprehension, etc. The quizzes are given to students in both online and on-campus classes, so these modes of course delivery can be compared.

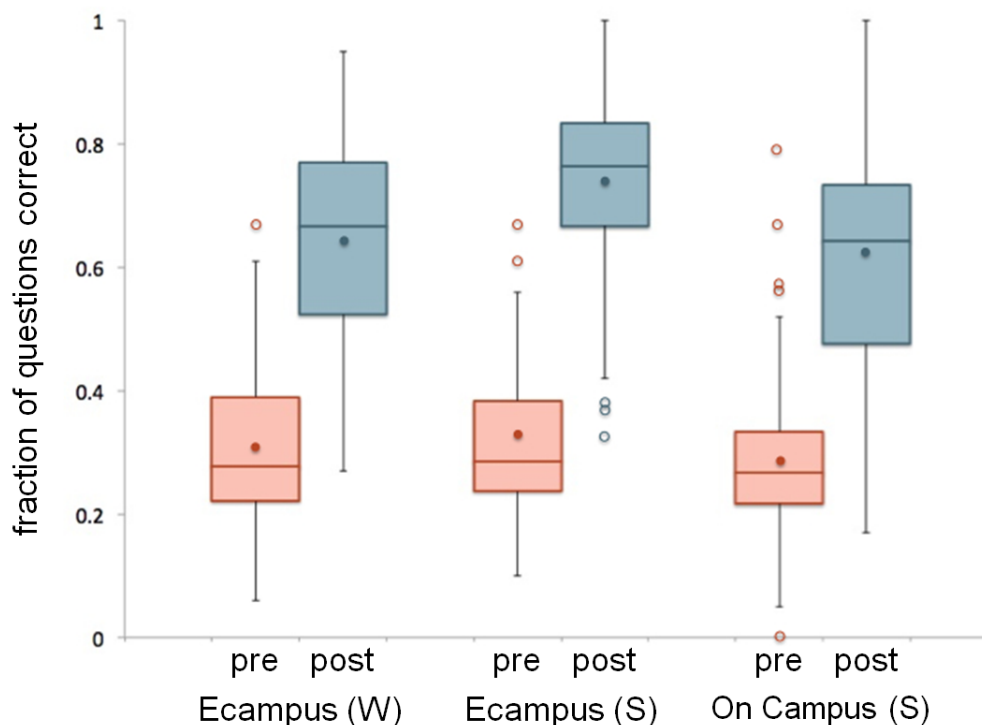


Figure 3. Cumulative scores for pre- and post-chapter quizzes in two Ecampus and one on campus section of OSU general chemistry. Box heights indicate the first and third quartiles. The median (line) and mean (dot) are shown inside boxes. Whiskers are the 1.5 x interquartile range (IQR); open circles are scores outside of 1.5 IQR.

As shown in Figure 3, our preliminary data on large student sections of online and on campus general chemistry both show large and significant increases in student learning, with no significant differences for the two delivery modes. The data shown are cumulative; however, the methodology allows us to address interesting issues such as the relative effectiveness of an online course and associated tools in specific content areas such as atomic structure or electrochemistry. This pre-

and post-quiz methodology is being expanded into the full online general chemistry program in the coming academic year; OSU expects to publish full results obtained in academic year 2013/14.

Finally, OSU Chemistry is monitoring outcomes directly associated with student success: How well do online students perform on exams and in subsequent classes as compared with traditional campus students? The exams given to students in both formats of instruction are similar (not identical; questions are often changed to discourage “sharing”), and equivalent grading rubrics are used for both delivery modes. All exams, for both on-campus and online students, are proctored to assure academic honesty. For online students, OSU’s Ecampus staff oversees a registration and confirmation process for a test center near the student’s home; only these approved proctors can provide students with access to password-protected exams on test dates. While data is not yet ready for publication (due to required institutional release), taking into account normal class-to-class variations, the grade distributions for on-campus and online classes are consistent. These outcomes are based on equivalent instructor grading rubrics.

Conclusions

As demand for online classes grows, more institutions will begin offering them, and advisors will be faced with the challenge of evaluating the quality of classes their advisees want to take. Criteria include:

- Classes offered by a well-respected public research university
- A strong history of successful teaching and learning
- Students have the support of an Ecampus department, which assists them with registration, proctoring, and other student needs
- A vigorous and expanding assessment program to ensure that course outcomes are met and all delivery modes perform to our standards

Oregon State University is glad to support your students by offering them a solid basis in chemistry on which to build their academic careers. Please contact us with any questions you may have.

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Michael Lerner is a Professor of Chemistry at Oregon State University and director of the department's online education program. His main research interest lies in developing new solid state materials with applications in batteries and supercapacitors.