

DEPARTMENT of CHEMISTRY UNDERGRADUATE PROGRAM REVIEW: FINAL REPORT

Oregon State University February 22-24, 2014

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1. OVERALL RECOMMENDATION: EXPAND THE UNDERGRADUATE PROGRAM IN ORDER TO IMPROVE THE MAJOR AND STUDENT ACCESS TO COURSES REQUIRED FOR MANY DISCIPLINES AT OSU.

2. SUMMARY OF FINDINGS AND RECOMMENDATIONS:

The Undergraduate Program in the Department of Chemistry in the College of Science plays dual roles at Oregon State University: providing foundational science instruction to support OSU's diverse programs, and delivering a vibrant major program that prepares students to enter careers and graduate/ professional programs. The undergraduate program review committee recognizes that Chemistry is the central science, and that improvements to this Department contribute to the University as a whole. The central nature of Chemistry's role is confirmed by the fact that 59% of OSU students take at least one chemistry class. However, this service load has impacted the UG Chemistry degree, as it is currently not able to increase its size based on faculty and facility constraints.

Strengths of the Program:

- Offers 10 Chemistry options that support many career paths; two are certified by the American Chemical Society.
- Innovative teaching, especially in the upper division integrated lab courses and Ecampus courses.
- Chemistry has implemented high impact, innovative programs for students who are struggling; they have equally strong programs for exceptional students.
- Chemistry's Ecampus program is unique, providing world-wide access to Chemistry courses and increasing the number of chemistry degree minors.
- Graduate teaching assistants have extensive teaching experience and are engaged in meeting students' needs; the department appears to provide good TA training.
- Undergraduate major students are very positive about the program. They are also enthusiastic about the staff and faculty, and all specifically mentioned the high level of support. Their main negative comment was that they sometimes have to wait to get into classes required for the major. Students in other departments taking service courses report high quality instruction.
- A large proportion of student majors (over 50%) are engaged in research, internship, and other experiential activities such as outreach. Since research expenditures are high for a faculty of this size with this teaching load, there are many opportunities for student research.

Challenges for the Program:

- The number of undergraduates to finish a degree in chemistry (30-36 graduates/year) is somewhat low relative to service load and total undergraduate population. However, there are serious impediments to growing the major, which include:
 - *Limitations of facilities:*
 - Gilbert Hall cannot be expanded to house modern chemistry laboratories, research, and teaching facilities, because of physical and cost limitations.
 - Teaching labs in Gilbert Addition need renovation.
 - New teaching labs in the Linus Pauling building are not equipped to teach upper division chemistry classes, as they do not have exhaust hoods.
 - Some courses required for Chemistry majors are frequently or always wait-listed:
 - CH 324 (taken by both majors and non majors): staffing issue
 - CH 361 (majors lab): facilities issue
 - *Limitations in tenure stream faculty:*
 - The size of the tenure stream faculty is the same as it was in 2003, although since then the university has grown considerably and student credit hours generated annually by Chemistry grew from 38,000 to 61,000.
- There is a high D/F/W rate in general and foundational chemistry classes, and instructional faculty and TAs noted frustration with lack of student preparation.
- Some service courses central to OSU's mission are frequently or always wait listed. Other departments requiring Chemistry courses report that their students are unable to complete their degrees in a timely manner due to inability to access upper division courses such as CH 324 and CH 337.
- Although "Mole Hole", CH 199, and other types of academic support are excellent for General Chemistry, similar support is not available for upper-division courses such as Organic Chemistry, and students frequently struggle with these courses.
- Currently, based on student credit hours generated, tenure stream faculty members teach more than faculty in other College of Science departments.
- Ratio of students to faculty is very high compared to the top 10 land grant universities.
- Assessment process, policy and practices are not formalized and visible to faculty, staff and students for continuous program improvement.
- Additional staffing is needed for undergraduate coordination.
- Instructional faculty and teaching assistants currently teach the new CH 199 class in the Physics "SCALE UP" classroom (student centered active learning environment for undergraduate programs), but this room is frequently unavailable, as it is in use by other departments.

Recommendations:

- Eliminate bottlenecks for upper division courses by expanding/improving facilities.
- Increase teaching capacity and access by increasing the size of the tenure-stream faculty.
- Enhance student success by adding and enforcing appropriate prerequisites for chemistry to reduce the high DFW rates.
- Require students to achieve a minimum grade in series or prerequisite courses in order to advance, consistent with trends in higher education.
- Consider efficiencies represented by simplifying the number of options in the chemistry major, moving to one core, eliminating at least one “layer” of non-majors chemistry such as honors college chemistry, and reducing the number of sections by moving into larger lecture halls.
- Scale back Ecampus offerings and do not develop additional Ecampus degrees and courses until staffing and access problems for on-campus students are solved.
- Support and enhance modern pedagogy by implementing additional “SCALE UP” teaching facilities, perhaps shared with other College of Science departments.
- Seek additional support from the College, other colleges, or the Office of Academic Success to increase the availability of tutoring for upper division Chemistry classes broadly required across many majors.
- Increase the level of FTE in staff doing undergraduate coordination.
- Interface with life sciences faculty in revising curricula to better serve life sciences students.
- Charge the Curriculum and Student Success Committees with standardizing and improving department-wide assessment.

In addition, the Undergraduate Review Committee was challenged by the Science Deans to identify “what a top 25 Chemistry Department would look like”. In response, we provide the following analysis:

By any measure of “top” universities, land grant institutions are well represented. For example, in the latest *US News and World Report* rankings, 12 of the top 50 universities are classified as land grant institutions. All 12 of these schools have Chemistry Departments that are rated in the top 100 for chemistry schools, world-wide (again, by *US News and World Report*). While one may quibble about the exact *US News and World Report* rankings, they nonetheless provide valuable metrics. What characterizes these departments and schools? On average, these schools graduate 105 chemistry majors per year, along with 59 graduate students (American Chemical Society). They average 52 tenure-stream chemistry faculty members (out of 2346 academic staff, on average -- 2.2% of the academic staff is tenure-stream chemistry faculty), teaching an average of 23,101 undergraduates (average undergraduate head count enrollments). Expressed as ratios, on average these schools graduate about 2.02 undergraduate chemistry majors and 1.13 graduate students per chemistry tenure-stream faculty per year. Overall, about 0.5% of the total undergraduate headcount graduates each year with a chemistry major in these schools. At the same time, the tenure-stream chemistry faculty members teach roughly 450 undergraduate students each, based on total average undergraduate head count.

Compared to these “Top 25” programs, OSU graduated 38 majors in 2013, roughly 0.15% of the undergraduate student headcount. These students were taught by 22 tenure-stream faculty, for a ratio of 1.73 majors/chemistry tenure-stream ratio. Both of these numbers are low against the comparison group. But, at the same time, the OSU tenure-stream chemistry faculty (comprising roughly 0.8% of the academic staff at OSU) taught about 1165 students, about 2.6 times the average load, against the comparison group.

Metric	12 Land Grant Universities that are ranked in US Top 50 universities and in the top 100 chemistry schools, world-wide	OSU
Undergraduate chemistry graduates/year, average	105	38
Percentage of total undergraduate enrollment that are chemistry majors	0.5%	0.15%
Tenure-stream faculty	52	22
Percent of total university academic staff that are Chemistry tenure-stream faculty	2.2%	0.8%
Number of undergraduate chemistry graduates per tenure stream faculty member	2.02	1.73
Total undergraduates taught per tenure stream faculty member	450	1165

Recommendations to achieve a higher ranking:

- A. Increase number of chemistry majors - greater emphasis on undergraduate recruiting and research opportunities.**
- B. Increase speed through the program (i.e., achieve higher 6-year graduation rates) - remove impediments toward timely degree completion.**

Impediments:

- For timely degree completion, majors must be able to enroll in required courses. As mentioned above, CH 361, a required majors lab, has a large wait list due to an inability of the department to offer more sections of this course until the teaching labs in the Gilbert Annex are properly renovated to handle the increased load. **THIS RENOVATION MUST BE A HIGH PRIORITY** in order to achieve an expansion in the number of majors, a key component of enhanced program recognition.
- A second impediment to expansion of the number of majors is the relatively small number of

tenure-stream chemistry faculty, relative to the comparison group mentioned above. **HIRING OF ADDITIONAL TENURE-STREAM FACULTY MUST ALSO BE A HIGH PRIORITY** to achieve an expansion in the number of majors, and a concurrent reduction in the overall student to faculty ratio (another important metric in national rankings). In order to *attract* new faculty and students, and to better serve the undergraduates attracted to the program, however, modernization and potentially expansion of research space and facilities must be addressed.

3. DETAILED FINDINGS

INTRODUCTION

The objectives of the review were to provide input into the development and health of the Chemistry Department undergraduate program at OSU. Both strengths and weaknesses were identified and clear recommendations were made concerning how the weaknesses could be mitigated or improved. The members of the review team were provided with the review schedule, the self-study by the Chemistry Department, guidelines for the review report, as well as several available reports or summaries:

- “Enrollment/Demographic Reports” - <http://oregonstate.edu/admin/aa/ir/enrollmentdemographic-reports>
- Graduation summaries - <http://oregonstate.edu/admin/aa/ir/retention-degree-graduation-reports#Graduation%20Sum>
- “Faculty/Staff Reports” - <http://oregonstate.edu/admin/aa/ir/faculty-and-staff-reports>
- OSU Chemistry homepage - <http://chemistry.oregonstate.edu/>

The committee met on February 23, 2015 and had a full day schedule, which included meeting with the Chair, the Dean of the College of Science, the Chemistry Chief Advisor and Assistant Chief Advisor, the Chemistry faculty, the Associate Dean of the College of Science, the Curriculum Committee, the Student Success Committee, undergraduates, and Graduate Teaching Assistants. The Committee also received a walking tour of Gilbert Hall/Annex and the Linus Pauling Science Center and an Ecampus overview. Upon arrival, the committee was provided with the Department’s Strategic Plan (adopted September 19, 2014), the past review of the graduate program (May 21, 2013) and the department response to that report. There was no previous review of the undergraduate program. The Chair provided a summary PowerPoint highlighting the accomplishments and challenges of the department, which was also made available to the committee. The committee had opportunities for questions and discussions with all parties that they met.

INPUTS

Mission: The mission of the program is documented in the Strategic Plan of the department. Parts of the mission that most directly concern undergraduate programs include providing: (i) A consistently modern educational experience for undergraduate Chemistry majors that prepares them for careers in an ever-evolving workplace; and (ii) High-quality curricular service to the University through innovative classrooms and on-line educational tools. The Chemistry Department mission supports the OSU mission of producing competitive graduates, creating new knowledge and rigorously promoting excellence, as well as promoting diversity. Chemistry foundation courses form the basis of curricula of numerous programs across the

campus in all three of OSU's Signature Areas of Excellence: Advancing the Science of Sustainable Earth Ecosystems; Improving Human Health and Wellness; and Promoting Economic Growth and Social Progress.

Demographics: The Department demographics mirror the overall College demographics, consisting of 21 tenure stream faculty, 1 professor of practice faculty member, 13 instructional faculty, 13 emeriti, and 17 staff members. There are approximately 120 graduate students, 25 postdoctoral and research associates, 200 chemistry majors, 800 chemistry minors and over 3000 students taking chemistry (59% of all OSU undergraduates take at least one course in chemistry) each year. The department graduates approximately 30 BS or BA graduates annually and over 300 Chemistry minors.

Recruitment and enrollment trends of students and admissions selectivity: The Chemistry undergraduate program is inclusive, admitting any student admitted to OSU. At this time, the Department is not recruiting undergraduates due to limitations in faculty time. Still, the number of undergraduate degrees awarded has grown 76% over the last 10 years. Course enrollments have grown faster over the last ten years than the University's rate of growth because of the increase in service courses. Currently, the department generates 61,000 student credit hours annually.

Curriculum and assessment strength: The undergraduate chemistry program is flexible, with 10 options, two of which are American Chemistry Society approved, and offers both a BS and BA. One of the highlights of its undergraduate education is the development and recent deployment of inquiry-based laboratories for the lower division students and integrated laboratories for upper division students. Chemistry's Ecampus program is unique, providing worldwide access to Chemistry courses and increasing the number of chemistry degree minors. There is also an academic support class for introductory chemistry, and an excellent program for high-achieving students.

Quality of personnel and adequacy to achieve mission and goals: The department survived a period of faculty attrition while still providing service courses by increasing the numbers of non-tenure-stream instructors. Chemistry instructors have a reputation for excellence and innovation on the OSU campus. However, compared to the students taught vs. number of tenure stream faculty ratio found in comparator and aspirational chemistry departments, OSU's ratio is badly skewed. This potentially limits the number of majors that can be handled by the department, while still achieving their goals of providing a modern and high quality educational experience in chemistry.

Level and quality of infrastructure: About two-thirds of the faculty and a significant portion of the teaching facilities are housed in Gilbert Hall, constructed in 1931, and Gilbert Hall Addition, constructed in 1981. About one-third of the faculty is housed in the new Linus Pauling Science Center, which also houses modern teaching labs for lower-division chemistry classes, and shared instrumentation. After a tour, the committee concurred with the self-study that Gilbert and Gilbert Addition badly need renovation, in some cases lacking basic safety features such as sprinklers in the labs. Even if renovated, structural limits will prevent Gilbert from ever housing modern chemistry research laboratories. Lecture halls in Gilbert are seriously out of date and in poor repair. The need for renovation of teaching labs in Gilbert Addition causes serious bottlenecks in class availability. Unfortunately, the LPSC teaching labs can't be used for upper division chemistry lab classes, as they lack fume hoods.

Quality of organizational support: The number of chemistry faculty is the same today as it was in 2003. During the intervening years, however, there was considerable attrition; only very recent reinvestment by

the College of Science led to rebuilding numbers of tenure-stream faculty back to the 2003 levels. During the same period, the number of instructors grew, and the number of student credit hours generated more than doubled. Staffing is low for a department with the number of undergraduate students taking its classes, which also include teaching labs with required prep. For example, one staff member with 0.5 FTE handles the coordination necessary for students to be registered and placed in classes each term.

OUTCOMES AND IMPACTS

4- and 6-year graduation rates for students: Chemistry's 6-year graduation rate of 27% (starting and graduating in Chemistry) is lower than College of Science's 6-year graduation rate of 36.2% (starting and graduating in College of Science). Similarly, Chemistry's overall 6-years graduation rate of 41% is considerably lower than the overall rate reported by College of Science of 62.6%. When asked, Chemistry leadership reported that these lower graduation rates are influenced by the relatively large number of incoming students that select Chemistry as a major before they know what a chemistry major requires, or understand their other choices. The committee notes that the very high D/F/W rates for Chemistry courses may also relate to the low graduation rates.

Student learning and outcomes and assessment of learning: There are four Program Learning Outcomes for the UG Chemistry major that align with individual assessments as defined by the UG Assessment Process. The outcomes are based on the knowledge and skills Chemistry graduates need to be prepared for future careers and graduate school. Formal assessment of UG Chemistry began in 2006 and continues annually. It took five years to complete one full cycle to administer all of the formal assessments of the UG program. The report did not explicitly state how assessment results impacted changes to instruction, courses, or outcomes. Both the Curriculum Committee and the Student Success Committee are new committees in the Department and have been in existence only for the past year.

Placement and success of graduates: The department reported that one-third to one-half of graduates obtain a further degree after graduation. A survey found that 94% of OSU Chemistry graduates work for pay, filling a variety of positions in education, health and industrial fields.

Satisfaction of students and graduates with their education and their post-graduation employment success: Most reported a high degree of satisfaction.

Student satisfaction with their education and mentoring experiences: Students expressed a high degree of satisfaction with Chemistry programs and staff. They felt strongly supported by the faculty and staff, who they characterized as extremely hard working and helpful. Some mentioned bottlenecks caused by waiting lists for required courses. They are dissatisfied with the quality of the building and labs, which they feel reflect poorly on OSU. Some students suggested that majoring in chemistry was for students who failed Engineering; this perception could be changed if Chemistry facilities were more attractive and modern.

Research and experiential learning: The relatively new CH 220 provides an exposure to research, careers and professional development to new chemistry majors. In addition, a special program for high-achieving students allows them to participate in early research. The required upper-division laboratory course sequence incorporates project-based learning, and includes a poster presentation. A survey found that 55% of chemistry majors have participated in research, 21% in internships. Students reported participating in a large variety of experiential learning activities, both within OSU and in the community.

Professional or national rankings/ratings: N/A. See discussion above.

EXPANDED DISCUSSION/EXPLANATION OF SPECIFIC RECOMMENDATIONS FOR IMPROVEMENT THAT MAY BE UNCLEAR

- Eliminate bottlenecks for upper division courses by expanding /improving facilities.

This will be partially addressed by renovations to Gilbert Addition.

- Consider efficiencies represented by simplifying the number of options in the chemistry major, moving to one core, eliminating at least one “layer” of non-majors chemistry such as honors college chemistry, and reducing the number of sections by moving into larger lecture halls.

The department may be able to identify ways to streamline course offerings, advising loads, numbers of sections, and the like that are consistent with departmental culture and do not compromise teaching excellence. The committee reports that other universities use larger lecture halls and night classes, and have dropped low-enrollment classes such as Honors College sections, to improve student access.

- Interface with life sciences faculty in revising curricula to better serve life sciences students.

The department has effectively interfaced with the College of Engineering, and provides courses tailored to engineering programs. As a large percentage of students that take chemistry courses are in a major related to life sciences, there may be ways in which chemistry courses could better serve these majors. As an example, recently the General Biology majors course sequence was revised so that students can now take it in any order, which removed barriers and will shorten the time to graduation for many students. Because Chemistry courses are prerequisite to many other courses, Chemistry could examine the feasibility of rearranging the order of topics in their General Chemistry curriculum, allowing students to start Organic Chemistry after completing the first 2 quarters of General Chemistry, or other innovations, to better serve life sciences majors.

- The Curriculum and Student Success Committees should be charged with standardizing and improving department-wide assessment to "improve student learning, student skills, and the effectiveness of the chemistry program". This could include:
 - Documentation of assessment process and policy to ensure continual program improvement.
 - Clear mission of the Curriculum Council and involvement in the assessment process and representation by advisors, instructors, faculty, and graduate students.
 - Alignment of ACS and UG Program formal assessments (e.g. exams, rubrics) for all options.
 - Measuring effectiveness of inquiry-guided instruction (or other innovative pedagogy) to student learning and meeting program outcomes.
 - Continual training and support in inquiry-guided instruction for all instructors and faculty.
 - Continual investigation of creative solutions to delivering instruction through different learning environments such as hybrid Ecampus/on-campus instruction or flipped classrooms.