Assessment Plan for Chemistry Undergraduate Program

Assessment Plan - Chemistry has identified seven Learning Outcomes that should be mastered by all of our Undergraduate students by the time of their graduation. These learning outcomes are applicable to both the B.S. and B.A. degrees as well as the Biochemistry emphasis. These learning objectives align with the Campus-wide Learning Outcomes (CWLOs) as identified below and with the standards of our national accrediting organization, the American Chemical Society (ACS).

Several **direct** assessment strategies are planned that fall into two categories: student performance on nationally-normed standardized tests available from the ACS Examinations Institute and examination of student written work from our Senior level Writing Intensive Course (CH 427), evaluated using specifically designed rubrics for that coursework. The issue of data quality from these sources is addressed below.

The assessment findings will be used for: 1) Exploration of the success of recent implementation of active classroom strategies in one of the two sections of Organic Chemistry lecture. 2) Exploration of the effectiveness of an Adaptive Online Homework system in one section of the General Chemistry lecture, 3) Exploration of the effectiveness of incorporation of a Data/Writing Workshop into the CH 427 course and its possible use as a model for the other advanced laboratories.

Curricular Alignments – The course map below shows the alignment of the identified Learning Outcomes (LO) with our curriculum, including the level at which the LO is addressed. The Chemistry LOs all clearly align with CWLOs #1 (Disciplinary Knowledge) and #2 (Critical Thinking). LO 6 is intended to connect with CWLOs 4 – 6 and is being addressed by Deliberative Democracy modules in the General chemistry sequence. The communication CWLO (#3) aligns with the last of our skills objectives (7H below).

Learning Outcomes:

1) Students will be able to demonstrate high level understanding of the linkage between structure, properties and reactivities of the chemical families (e.g., organic, inorganic compounds).
2) Students will be able to demonstrate an understanding of the physical principles of chemical bonding, thermodynamics, and quantum mechanical effects.
3) Students will be able to demonstrate understanding and apply the principles of reaction kinetics, including mechanistic level descriptions.
4) Students will be familiar with the basic principles of chemical analysis and will have a working knowledge of the wide array of instrumentation used in modern science.
5) Students will be familiar with the logical process of planning a synthetic route to produce a desired chemical and will have a "toolbox" of common syntheses for organic and inorganic targets.
6) Students will have had exposure to the societal and global implications of chemistry and other sciences with some emphasis on the connection between science and public policy.
7) Students will possess a set of skills needed by practitioners of modern chemical science, including the following:
   A) Locating, critically reading and interpreting the primary chemical literature
   B) Planning and executing experiments based on the literature
   C) Anticipating, recognizing and properly responding to hazards in the lab and industry
   D) Keeping legible, complete, accurate and defensible experimental records
   E) Performing synthesis and basic confirmation of inorganic and organic compounds
   F) Designing and implementing quantitative chemical analysis using "wet" and instrumental methods
   G) Analyzing data and assessing the reliability of the results
   H) Interpreting and effectively communicating the results of experiments (oral and written forms)

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Assessment Activities

The Chemistry department has been administering the nationally-normed standardized Organic Chemistry exam from the ACS Examinations Institute for decades. This historical data can be examined to determine the effectiveness (at a course-level scale) of the implementation of active-classroom strategies in one of the two large lecture series in the last five years. Comparisons can also be drawn between the two concurrent lecture sections, since one is led by an instructor that has not adopted any of the newer evidence-based methods.

The ACS is offering an opportunity to participate in the trial period for a new standardized General Chemistry exam that could be used near the end of the three term sequence to investigate how our students compare to those at other Universities and Colleges, as well as to explore differences in student performance between the two large mainline lectures and/or with the "trailer" sequence. Differences between the sections that could be explored to investigate potential routes to improvement of student performance include the adoption of an Adaptive online homework system (ALEKS) in one or more of the sections. Incorporation of this test will require some lead time, so it is envisioned that this would happen in the Spring of 2019 at the earliest.

Finally, multiple years of student writing samples and the very detailed rubrics that were used to evaluate them for the CH 427 Instrumental Analysis WIC class are warehoused on the D2L platform. Two years ago the class was changed from 2 to 4 credits and a twice-per-week workshop was added to support student writing and data analysis. Analysis of student performance (from the rubrics) can be used to judge the effectiveness of this modification.

Data Quality

The nationally-normed standardized exams from the ACS Examinations Institute are committee-developed materials that assess the common content that should be covered within a given chemistry course or course sequence. These examination materials undergo beta testing with colleges and universities from across the country and the published materials represent the outcome of rigorous test analysis. These examination materials are held in high regard at institutions across the country. As the ACS Examinations Institute regularly collects data from a variety of institutions, individual student and whole class scores at PSU can be compared to the normative data.

The rubrics that are used to evaluate student writing in CH 427 were originally obtained from University of Wisconsin Writing Center's scientific writing website. We then customized them over several years to contain specific examples of high to low-performance response to each item in the rubric (as well as customization of the items). Samples are available upon request. A single graduate student teaching assistant is assigned the evaluation of each report during the term to maintain reliability. A statistical analysis of the differences between graders from a given year and between years did not indicate significant differences in the application of the rubrics to student writing evaluation.

Assessment Findings

The examination of the historical and head-to-head results of the ACS Organic Chemistry exam scores can be used to determine whether the addition of Active-Classroom strategies improves student performance.

The adoption of the ACS General Chemistry exam (if feasible) would allow a number of interesting explorations of the impact of active classroom strategies: 1) Comparison of the more lecture-focused trailer section with the active learning on sequence sections, 2) Evaluation of the implementation of Adaptive homework software, and 3) Comparison of explorations 1 and 2 by various demographic groups.

If valuable lessons are learned from the investigation (and possible implementation for General Chemistry) of the results of the standardized tests, a broader discussion of their possible use in higher level chemistry

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classes and/or of the use of the ACS Diagnostic Undergraduate Chemistry Knowledge test as a program-wide evaluation of the attainment of these Learning Outcomes will be initiated. The examination of the writing samples and rubrics can be used to judge the effectiveness of the incorporation of the workshops into the Instrumental WIC class and if this shows promise, discussion of the expansion of this model into some of the other higher-level Chemistry lab courses can be initiated with the responsible faculty.

Curriculum Map for Chemistry:

Chemistry Course Matrix for Student Learning Objectives

		General Chemistry		Analytical Chemistry				Organic Chemistry			Physical Chemistry			Inorganic Chemistry			Biochemistry*	
	Courses:	Lecture (221 -223)	Lab (227-229)	320	321	426	427	Lecture (334-336)	337	339	Lecture (440-442)	443	444	411	412		Lecture (490-492)	493
Learning Outcomes																		
1	structure/reactivity	1		1		2		3			3			3	3		3	
2	theory	2		2		2		2			3			3	3		2	
3	kinetics	1		0		1		3			3			0	2		3	
4	analysis	1		2		3		2			2			2	2		2	
5	synthesis	0		0		0		2			1			1	2		2	
6	societal	2		1		1		1			1			1	1		1	
7	skills	as below for all labs																
Objectives under LO 7																		
A	literature		1		0		3		1	2		0	2					2
B	exp. design		2		1		2		2	2		1	2					2
C	safety		2		2		2		3	3		0	3					3
D	record-keeping		2		2		2		3	3		2	2					3
E	synthesis/charact		2		0		1		2	3		0	1					2
F	quant. Anal		1		2		3		1	1		3	2					1
G	data analysis		2		2		3		2	2		3	3					2
H	communication		2		1		3		2	2		2	3					3
	Taxonomy Level:																* Biochemistry can be taken by the traditional Chemistry majors, but is not required. Biochemistry majors are not required to take CH 443, 444, or 411	
0	not covered																	
1	introductory only																	
2	practice/verification																	
3	synthesis/evaluation																	