

Department of Chemistry
Learning Outcomes Assessment Report
2008 - 2009

I. Introduction:

The chemistry department is a department characterized by a relatively young faculty, most of which have been hired in the past 10 years. The department is divided into sub-discipline specialties including: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry and physical chemistry. The department also has a faculty member who specializes in science education. As reported in the 2007-2008 assessment report, our course structure and teaching methods are in a state of change due to the addition of new faculty. Additionally, the chemistry department offers American Chemical Society certified Bachelor degrees in chemistry. To maintain accredited status, the department must adhere to the guidelines and evaluation procedures established by the ACS Committee on Professional Training. Learning outcomes and assessment practices are addressed within these guidelines. We are currently preparing our five year program review report for submission in early July. We anticipate a favorable review. The outcome of this report will be included in our 2009-2010 assessment report. During the 2008-2009 academic year, the chemistry department continued its major assessment of capstone projects through the departmental poster session. During the spring semester, there were over 40 posters assessed. We also utilized American Chemical Society standardized exams in CHEM 124, and CHEM 160B. The utilization of a standardized exam in CHEM 160B, second semester biochemistry lecture, represents a new assessment tool in order to provide information regarding student learning in our biochemistry major concentrations specifically. Additionally, the department embarked upon a revision of our MS graduate program in chemistry and biochemistry. This policy revision is at this point incomplete, but already includes built in assessment plans for the graduate program. These were preliminarily implemented this year. Both the biochemistry and graduate assessment components will be incorporated into the chemistry department assessment plan for formal departmental adoption during the 2009-2010 academic year.

Undergraduate Assessment:

II. Learning Goals:

Students are expected to develop their competence in eight skill areas. Five of these are transferable skills taken from general education courses and three are more specifically aimed at students majoring in Chemistry.

- Effective Writing
- Effective Oral Communication
- Critical Thinking (logic and rhetoric)
- Problem Solving and Critical Thinking
- Quantitative Analysis
- Library and Scientific Information Literacy
- Computer literacy
- Laboratory Skills

III. Specific Learning Outcomes:

A. Laboratory Knowledge and Skills.

Students obtaining a baccalaureate chemistry degree should have upon graduation:

- 1) the basic analytical and technical skills to work effectively in the various fields of chemistry.
- 2) the ability to perform accurate quantitative measurements using modern chemical instrumentation, interpret experimental results, perform calculations on these results and draw reasonable conclusions.
- 3) the ability to synthesize, separate and characterize compounds using modern methodologies and instrumentation.
- 4) knowledge and understanding of the issues of safety regulations in the use of chemicals in their laboratory work.

B. Computer, Library and Information Skills.

Students obtaining a baccalaureate chemistry degree should have upon graduation:

- 1) the ability to make effective use of the library and other information resources in chemistry, including the primary literature, tabulated data, and secondary sources such as the internet.
- 2) the ability to make effective use of computers in chemistry applications using standard and chemistry specific software packages.
- 3) the ability to perform and interpret simple molecular modeling or chemical computations using standard software.

C. Oral and Written Communication Skills in Chemistry.

Students obtaining a baccalaureate chemistry degree should have upon graduation:

- 1) adequate skills in technical writing and oral presentations.
- 2) the ability to communicate scientific information in oral and written formats to both scientists and nonscientists.

D. Quantitative Reasoning Skills.

Students obtaining a baccalaureate chemistry degree should have upon graduation:

- 1) ability to accurately collect and interpret numerical data.
- 2) ability to solve problems competently using extrapolation, approximation, precision, accuracy, rational estimation and statistical validity.
- 3) proficiency in the scientific method (formulating hypothesis and arriving at appropriate answers and conclusions.

E. Knowledge of Chemical Principles and Facts.

Students obtaining a baccalaureate chemistry degree should have upon graduation:

- 1) a working knowledge of chemical principles appropriate to a chemistry degree program to include thermodynamics, equilibrium, kinetics, quantum mechanics, structures of materials, reactivities of substances, and synthesis.
- 2) a mastery of a broad set of factual chemical knowledge concerning the properties of substances, molecules and atoms.

IV. Assessment Methods:

The degree path in the chemistry degree is a linear program in which content material and complexity of material is strongly dependent on previous and pre-requisite courses. As a result, the majority of the learning goals stated in section II are introduced in lower division courses and expanded upon in the subsequent courses as the student's knowledge and skill base increases. Although assessment of learning goals is performed in each course in the chemistry curriculum through grading of written and examination materials, the chemistry department has elected to perform an in-depth broadly-based assessment at two points in the major, one at the midpoint and the another toward the end of the degree.

- A. Assessment of Capstone Projects.** Examination of the above stated learning goals indicates that goals can be effectively assessed utilizing laboratory-based Capstone Projects. Capstone Projects involve developing experimental design, establishing the protocol, and executing the laboratory project in collaboration with a faculty mentor. Students present the methods, analysis and findings in a scientific poster presentation. Items A-D are assessed through departmental assessment of the posters by the full-time chemistry faculty. Each faculty member is responsible to assess 4- 5 posters utilizing a common rubric. The assessment rubric is identified only by the course are collected and tabulated for analysis. During the 2008-2009 academic year the following courses included capstone projects for assessment: CHEM 125 (Advanced Organic Chemistry Laboratory), CHEM 133 (Chemical Instrumentation), CHEM 141 (Physical Chemistry Laboratory), and CHEM 164 (Advanced Biochemistry Laboratory).

Rubric for Assessment of Capstone Posters

Overall the student's presentation shows that the student: (ratings: strongly disagree, disagree, no opinion / not applicable, agree, or strongly agree).

1. demonstrates effective organization of their poster (shows effectively the problem and how problem was attacked and solved)
2. demonstrates effective use of graphs and other visual aids
3. uses effective writing (good grammar, spelling, coherent writing, clear exposition)
4. shows an ability to use instrumentation useful in solving or doing problem
5. collected reasonable data useful in solving or doing the problem
6. uses literature properly in presentation
7. supports their generalizations and conclusions with adequate and sound evidence
8. uses technical vocabulary correctly
9. demonstrates effective learning of several laboratory skills
10. overall impression of the poster presentation. (ratings: poor, fair, average, good or outstanding).

- B. American Chemical Society Standardized Testing.** Although Learning Goal E, Knowledge of Chemical Principles and Facts, may also be assessed within the Capstone assessment activity, we elected to administer standardized exams in two courses during the 2008-2009 academic year. We elected to administer the American Chemical Society exam covering the full year (two semester sequence) of organic chemistry as the final exam in CHEM 124 (Organic Chemistry Lecture

II). This course is taken by all chemistry majors irrespective of concentration and represents a lecture course taken at the midpoint of the chemistry degree. During the 2007-2008 academic year, the department administered the ASC standardized exam in CHEM 110 (Advanced Inorganic Chemistry) as a comparison for student content knowledge at a point at the end of their academic career. The results of this year's results on that exam for 2008-2009 are not reported as a consequence of a faculty member leaving the university prior to providing the data. It is our intention to re-implement the standardized exam in CHEM 110 during the fall 2009 semester.

V. Assessment Results:

A. **Capstone Poster Results.** During the 2008-2009 academic year 41 capstone posters were assessed using the common rubric. The rubric is provided as an attachment and contains ten assessment ratings that are linked to the departments learning goals. The assessment scale ranges are Strongly Agree, Agree, No Opinion, Disagree, Strongly Disagree. In analyzing the data, numerical scores were assigned to the assessment scales, where 5 corresponds to Strongly Agree and 1 corresponds to Strongly Disagree. Using the assigned numerical scores, averages were obtained and are provided in Table 1 below:

Table 1. Capstone Poster Assessment Summary

Course	CHEM 125	CHEM 133	CHEM 164	CHEM 141	CHEM 198
Question					
1	4.3	4.8	4.1	4.9	4.9
2	4.6	4.2	4.1	4.6	5.0
3	4.5	4.3	3.7	4.6	4.9
4	4.5	4.6	4.4	4.6	4.9
5	4.6	4.6	3.9	4.4	4.9
6	4.0	4.0	3.9	4.6	4.7
7	4.6	4.2	4.0	4.6	4.9
8	4.6	4.4	4.4	4.7	4.9
9	4.6	4.7	4.0	4.6	5.0
10	4.2	4.1	3.6	4.4	5.0
Average	4.4	4.4	4.0	4.6	4.9

B. American Chemical Society Standardized Exam Results.

1) **Organic Chemistry CHEM 124.** Two sections of CHEM 124 were given the American Chemical Society Comprehensive Test in Organic Chemistry. The exam covers material from the two semester organic chemistry sequence. Table two contains the results of the exams:

Table 2. Results of Standardized Exam in Organic Chemistry

Section	Students	Average Score	Percentile	National Average Score
1	66	39.8	52%	39
2	55	35.3	42%	

Note: CSUS High score = 59 94% percentile based upon national reporting.

VI. Discussion of Assessment Results:

- A. General Comments.** Examination of both the Capstone Poster Project assessment results and the results of the standardized American Chemical Society exams establishes that the Chemistry Department is a) effectively meeting the its learning objectives and b) comparing favorably when compared to other chemistry departments in the nation who took part in the standardized testing.
- B. Capstone Project Results.** Closer examination of the Capstone poster project results shows that in all classes considered, students are meeting the learning objectives defined by the department. It is interesting to compare the CHEM 125, CHEM 141, and CHEM 198 results. The data shows an increasing trend as students progress from CHEM 125 to CHEM 141 and then CHEM 198 using a common rubric. In the chemistry program, there is typically a semester or more as students progress linearly through this series. It is clear from the data that the students improve significantly as a function of progressing through the program. This is to be expected since the students in CHEM 125 are at the sophomore or early junior level standing, compared to late junior or early senior level status of CHEM 141 students. CHEM 198, senior research is typically one of the last courses students take in pursuit of the BS Chemistry degree. Student experience in CHEM 125 is likely a first experience in completing and presenting independent experimental chemical work for many students. They have little experience using the scientific literature, writing in a scientific fashion, and a considerably less accomplished "scientific vocabulary" compared to the CHEM 141 students. CHEM 198 students have typically spent a semester (typically longer) working in a faculty research lab working alongside of graduate students and the faculty PI. The chemistry experiences leading up through this last cumulating experience clearly shows the students meeting the learning objectives set forth by the department. Use of the scientific literature is a main learning objective in CHEM 141. Although students in CHEM 133 and CHEM 164 are clearly meeting the learning objectives set forth by the chemistry program, comparisons using CHEM 133 and CHEM 164 are less transparent since most CHEM 164 students are BA biochemistry students and are not required to take CHEM 125, CHEM 133 or CHEM 141.
- C. Standardized Test Results.** Examination of the standardized ACS test results shows that the Chemistry Department compares favorably compared to the national average. Both sophomore and senior level assessment outcomes are at the National Average using the same exams. This suggests that both our lower

division and upper division courses are effectively meeting the learning objectives of our certifying agency and the chemistry department.

CHEM 124 (Organic Chemistry) Faculty Comments: This was the second year that the American Chemical Society standardized exam was administered in CHEM 124. The exam covers the two semester sequence of material covered in CHEM 24 and CHEM 124. Our results this year compare favorably with the results obtained last year. Student performance continues to compare with the average performance at the national level on the same exam. Two faculty members note that our students continue to perform well on the spectral analysis and reaction mechanisms. They also continue to perform well on questions related to the selection of reagents for reaction completion. High performance in these areas is to be expected since our program places emphasis on the practical application of organic chemistry. Our students struggled most with material taught during the first semester course and on topics that traditionally are most challenging for all organic students. The organic faculty will now evaluate the two year exam results in order to determine if course or teaching modification is warranted.

CHEM 160B (Biochemistry): Student performance in the year-long biochemistry sequence CHEM160A/B was assessed in 2009 for the first time using the American Chemical Society Exam Institute Biochemistry 2007 Exam. A total of 36 students took the 60 question, two-hour exam as the course final. The assessment is limited to this single year; nonetheless, analysis of student performance on the exam can provide a preliminary indication of overall student performance in the biochemistry program.

Although the ACS Exam Institute has not received sufficient scores on this exam to provide a validated national normalization, CSUS student scores were compared to the all national scores received to date. Figure 1 illustrates a comparison of CSUS students to the scores reported to date nationally. The overall mean and standard deviation for CSUS students (31.9 ± 7.35) were similar to those for the national scores reported to date (32.6 ± 8.9 ; Figure 1). As expected, student scores on the ACS Exam final correlated ($r^2=0.44$) with each student's average score for the three midterm examinations administered throughout the spring semester.

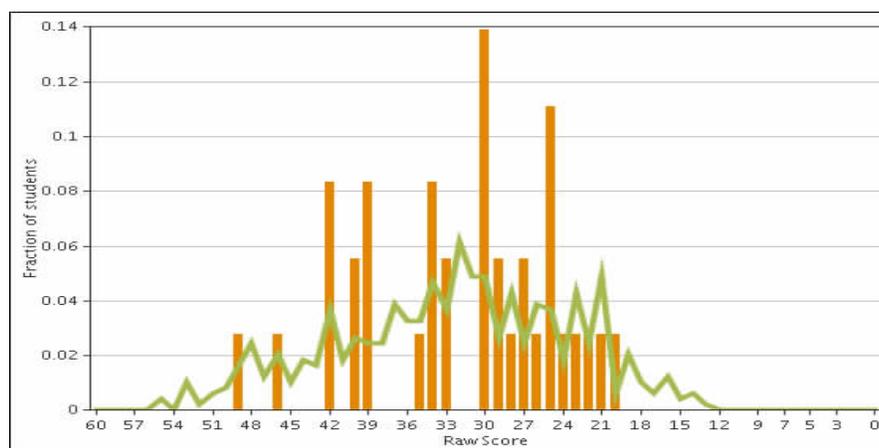


Figure 1. Comparison of performance of Sacramento State students (bars) to that of students taking the ACS Biochemistry exam nationally.

A cursory examination of the results of the biochemistry standardized exam compared to the reported scores nationally shows that our student performance compares favorably to performance of other students taking the exam.

VII. Future Plans:

- A. The current chemistry department assessment plan is well-developed to assess the learning outcomes of the BS chemistry program. In this regard we believe the program is clearly meeting the high standard of student learning the chemistry department and the American Chemical Society have established as desirable. We will discuss the assessment outcomes at our department retreat in August. In contrast, our current plan is less well-suited for application to the BA Biochemistry Degree. Although we have implemented the use of the ACS biochemistry standardized exam to assess student performance in lecture content material and we include CHEM 164 (second semester biochemistry lab) posters in our capstone assessment, we need to examine more closely our stated learning goals associated with the biochemistry majors. This is particularly important in light of the fact that the chemistry department has been approved to offer a new degree, BS Biochemistry, effective fall 2009. We will begin discussions regarding our assessment plan in the fall 2009.

Additionally, our current plan does not address learning goals and assessment of our MS graduate programs in Chemistry and Biochemistry. We have begun some discussion of graduate student performance using our standard placement exams in organic and physical chemistry to evaluate student competence entering the program, faculty evaluated literature seminar, research thesis and defense. The graduate committee has modified its graduate policy to include these assessment items and will begin drafting an addendum to the department's assessment plan

during the fall semester. The modified assessment plan will be presented to the department for considered adoption fall 2009.

- B.** Department discussion involving utilization of alumni survey data in learning outcomes assessment. The recruitment and retention committee is in the process of developing this survey.

- C.** Department discussion involving development and implementation of a graduating senior exit survey for use in learning outcomes assessment. The recruitment and retention committee is developing this survey in parallel to the alumni survey noted in item B.

Original Poster Project Assessment (Chemistry Department Spring 2009) PLEASE ASSESS 4 POSTERS

Course _____

Evaluator _____

Overall the student's presentation shows that the student:

1. demonstrates effective organization of their poster (shows effectively the problem and how problem was attacked and solved)

SD D A SA NA

2. demonstrates effective use of graphs and other visual aids

SD D A SA NA

3. uses effective writing (good grammar, spelling, coherent writing, clear exposition)

SD D A SA NA

4. shows an ability to use instrumentation useful in solving or doing problem

SD D A SA NA

5. collected reasonable data useful in solving or doing the problem

SD D A SA NA

6. uses literature properly in presentation

SD D A SA NA

7. supports their generalizations and conclusions with adequate and sound evidence

SD D A SA NA

8. uses technical vocabulary correctly

SD D A SA NA

9. demonstrates effective learning of several laboratory skills

SD D A SA NA

Key

SD: Strongly Disagree

D: Disagree

A: Agree

SA: Strongly Agree

NA: Not Applicable

10. Overall impression of the poster presentation. Please rate your overall impression

1 (poor) 2 (fair) 3 (average) 4 (good) 5 (outstanding)

Student Knowledge Inventory Results:

Mineralogy/Chemistry

1. The most common minerals in the earth's crust are the _____ .

Answer	All Students	G102A	G111A
Silicates	91%	91%	91%
Carbonates	7%	9%	0%
Sulfides	0%	0%	0%
Halides	0%	0%	0%
Sulfates	2%	0%	9%

2. _____ of an element are atoms containing different numbers of neutrons but the same number of protons.

Answer	All Students	G102A	G111A
Ions	11%	12%	9%
Isotopes	89%	88%	91%

3. Normal faults occur where

Answer	All Students	G102A	G111A
horizontal shortening	7%	6%	9%
horizontal extension	60%	67%	36%
hanging wall moves up	20%	15%	20%
footwall moves down	13%	12%	19%

4. Features found at subduction zones includes all of the following except

Answer	All Students	G102A	G111A
volcanoes	0%	0%	0%
oceanic trench	9%	6%	18%
faults	0%	0%	0%
rift valleys	86%	88%	81%
earthquakes	4%	6%	0%

5. To determine the numerical age of an igneous rock, geologists use

Answer	All Students	G102A	G111A
carbon-14	13%	12%	18%
radioactive isotopes	80%	79%	81%
cross-cutting	2%	3%	0%
superposition	4%	6%	0%

111A

The students did well on (percent correct):

silicates are most common minerals 91%

isotopes 91%

subduction zone features 82%

radiometric dating 82%

labeling plate boundary features 89%

They did middling well on:

Geologic history 72% (mostly not recognizing unconformities)

They did not do so well on:

igneous rocks 62%

They did disastrously on:

normal faults 36%

Students with weak fundamentals: Jackie Moore, Roxanne Dilley

G102A

The students did well on (percent correct):

silicates are most common minerals 91%

isotopes 88%

subduction zone features 85%

labeling plate boundary features 85%

They did middling well on:

radiometric dating 79%

Geologic history 76% (mostly not recognizing unconformities)

They did not so well on normal faults: 68%

They did disastrously on igneous rocks: 30%

I'm not sure if they don't know their rocks, or if they don't know what felsic and mafic mean. There were a lot of igneous rock names entered in the wrong slots on the chart.

A few students had metamorphic rock names in the chart. The igneous rocks they knew the best were granite (44%) and basalt (56%)

It also became clear we have a few students who are apparently weak on the fundamentals: Suzy Mejdrich, Jessica Wood, Rich Redd, Mark Fossi, Mike D'Anna, Mikey Elliott, Robert Lowery.

