Assessment of Learning Outcomes: AY15-S16 Summary
USF, BS, COLLEGE OF ARTS & SCIENCES
On-campus program

The report consists of course LO assessments edited by the chair (full course reports are filed with the Assessment Chair).

Course assessments are for all students in Courses Chem 1xx and 2xxx.
Course assessments are for chemistry majors in Courses Chem 3xx and 4xx.

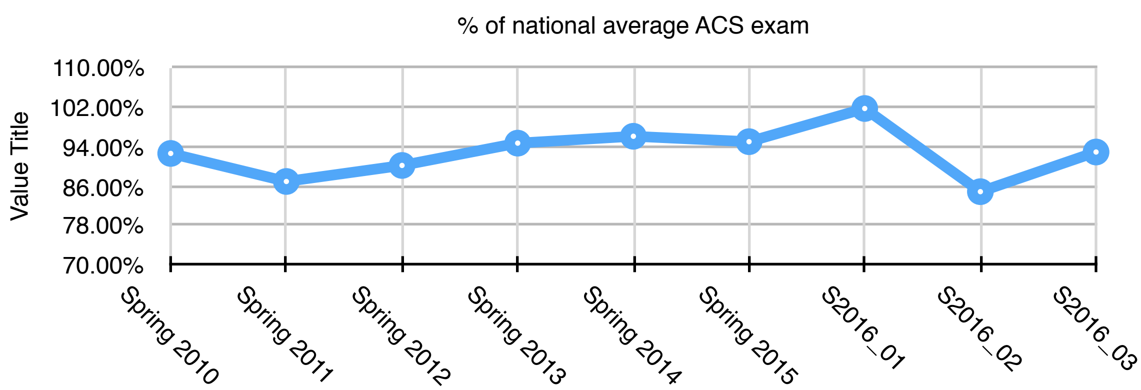
Complied and edited by LD Margerum, Assessment Chair, Summer 2016

LO #1: Students will demonstrate their mastery of the four principle disciplines: analytical, organic, physical, and inorganic chemistry (and biochemistry for that concentration). Aligns with Institutional Learning Outcome 3 (Students construct, interpret, analyze, and evaluate information…)

General Chemistry II 113 (Margerum, General Chem Faculty):

Experimental: The Full year American Chemical Society (ACS) Standard National Exam resulted in an **Average performance** that was consistent for the last 3 years (2016 = 93%). Benchmark is the national average (100% = 37.4 out of 70) was within the standard deviation of +/-9.2.

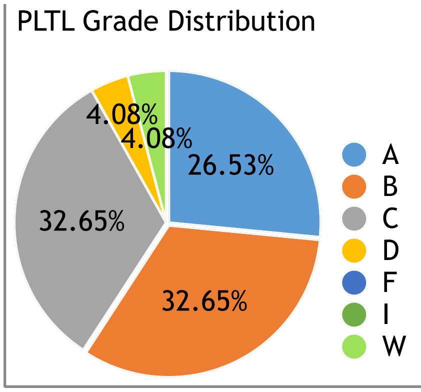
OnLine Web Based Learning (OWL): Provides many assessment reports. Here is a sample of areas for improvement based on course outcomes. Students get multiple attempts at the concept (one Chem 113 section):

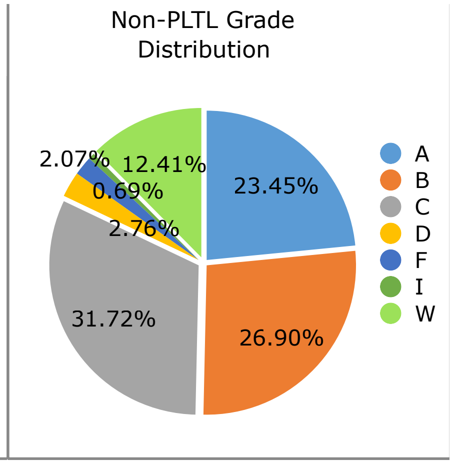


OWL: areas to emphasize and review next time (partial list)	Question	Ave Class	National
Characterize the properties of solutions and the factors that control the solubility of a solute in a solvent.	13.104	56.41%	45.26%
Describe colligative properties of solutions both quantitatively and qualitatively.	13.104	56.41%	45.26%
Determine the rate of a reaction and its dependence on concentration, time, and temperature.	14.038	58.97%	67.45%
Use the principles of thermochemistry to predict energy exchange during physical and chemical changes.	18.088	50.45%	53.13%
Determine standard and nonstandard reduction potentials.	19.062	49.71%	43.66%
Determine whether equilibrium has been established and calculate equilibrium concentrations.	17.107	28.85%	22.29%

Chem 191 (PLTL for Chem 111) (Margerum):

Optional 2-hr/ week peer led workshop (1 unit, pass/fail).
Compared exam grades for PLTL (n=47) vs. non-PLTL students (n=194-47).**The DFW rate for PLTL students was 8.16% while the DFW rate for the general population of chemistry students was 17.24%** (as the table shows, the %DWF varies a bit from year to year (compiled by Tiffany Tee, PLTL Assistant)





	2012	2013	2014	2015	2012-2014 Average	Difference with 2015
PLTL Average GPA	2.917	2.43	2.657	2.8	2.668	0.132
%DFW for PLTL	0%	13.79%	19.15%	8.16%	11%	-2.82%

What will be done differently in Chem 191 as a result of what was learned?

We need to fill all of the slots (n=60) to improve retention in Chem 111. The leaders and students were given mid-semester evaluations, where the leaders suggested PLTL incorporate letter grades (A-F scale), rather than the current pass/fail system. The students desired more lecture homework time and expressed concern for the non-alignment of PLTL content with general chemistry lecture content, as well as with the confusion in PLTL workshop problem wording. The latter concern was addressed in spring 2016, going to letter grade for Chem 191 is being considered.

Organic Chem 230 (Spector summarizing):

We embedded the same questions on the final for the three sections related to course Learning Outcomes (Mastery). **Our benchmark is 60%**

121 students	Structure/Mechanism	Spectroscopy	Synthesis	Acid/Base
Sec 1 (%) n=42*	47%	60%	55%	59%
Sec 2 (%) 38*	55%	61%	59%	68%
Sec 3 (%) 41*	60%	75%	64%	78%
Average	**54%**	**65%**	**59%**	**68%**

We have met, or almost met, our benchmark (60%) for the accessed questions, except for the Structure/ Mechanism question. There is also some variability from section to section. All sections did a significant amount of in-class and homework problems practicing these skills. Therefore the difference between the sections is due to a number of factors:

- a greater percentage of less prepared students in a particular section
- variable emphasis on a particular topic
- partial credit on the accessed final exam questions
- the specific problem used to test this skill on the final relative to what was during the semester

The acidity data was broken out to access the student's ability to a) qualitatively determine the most acidic protons on a given molecule (acidity) and b) qualitatively (without pKa values) determine which way the equilibrium of an acid/base reaction will lie and draw the mechanism for the acid/base reaction.

Breakout Acid/Base Data	Acidity	Acid/Base Reaction
Sec 1 (%) 42*	41%	70%
Sec 2 (%) 38*	55%	80%
Sec 3 (%) 41*	68%	80%
Average for all sections	**54%**	**87%**

Conclusions

Students were best at solving the acid/base problems. This is not surprising because students learned a significant amount of acid/base chemistry in previous courses and we are building on their previous knowledge.

In contrast, students encounter mechanism drawing, solving NMR spectra and multistep synthesis for the first time. Although the mechanism data shows lower achievement than the synthesis data, we believe this is anomalous this year due to a more difficult problem (not the best choice for assessment of a reasonable mechanism). Learning to solve multistep synthesis problems can be a particularly daunting skill for organic chemistry students and requires applying higher order problem solving skills.

What will be done differently in Chem 230 as a result of what was learned?

We will re-examine the type of problem to be assessed to obtain better data and emphasize to students that they will be using this in the next course. Therefore, Chem 230 experience is put to use in Chem 231 Organic II where an end of the semester goal is to solve 8-10 step syntheses (including protecting groups).

Organic Chem 230 (Castro summarizing):

Experimental: We embedded the same questions on the final for the three sections of the organic chemistry II lecture. Due to errors and lack of consistency in the spectroscopy questions, this was not assessed.

Results and Discussion

	Mechanism	Theory	Synthesis	Acidity
Section 1 (TS, n=32)	54%	87%	78%	82%
Section 2 (WK,n=22)	56%	82%	83%	57%
Section 3 (CC, n=22)	67%	85%	87%	42%
Weighted Average (last year ave)	58% (61%)	85% (78%)	82% (49%)	63% (77%)

Several key points emerge from the data:

1. All sections (three experienced instructors) had results in "Synthesis" that far exceeded the benchmark (60%) and the results from last year. They made sure VERY SIMILAR synthesis problems were given.
2. The choice of questions to assess acidity were poorly chosen and not graded consistently. It should be noted that section 3 (CC) had a very low score (47%) which is not consistent with prior years with the same instructor.
3. Typically there is a correlation for students who understand acidity and better on mechanismsHowever in section 3, students did the worst on acidity, yet performed the best on the mechanism.

There was a textbook change that two instructors were using this text for the first time. All instructors felt that new text did not emphasize mechanisms as well.

Conclusions: Strength: across sections, students were able to perform multi-step synthesis problems very well! Also, while student understanding of basic theory (eg, aromaticity) was strong, this did not translate into strong performances on both the mechanism and acid/base questions. This may be in part be due to (1) the questions chosen for acidity and mechanism topics and (2) the use of a new textbook.

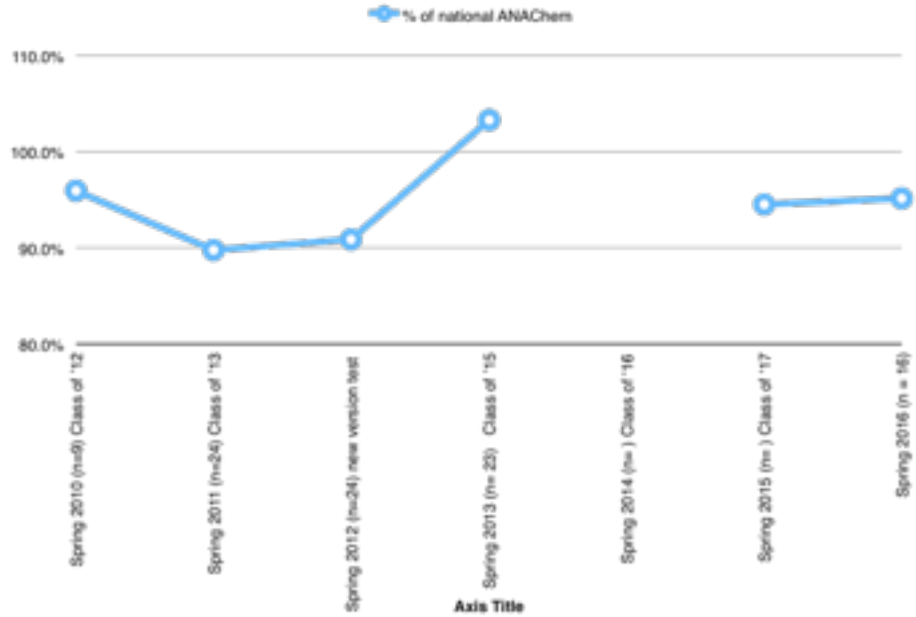
What will be done differently as a result of what was learned?

1. New questions for acid/base and mechanisms.
2. Faculty need to be absolutely consistent in their grading-(LM: group leveling meeting?)
3. Handouts with mechanistic problems should be shared; use similar questions on midterms.

Analytical Chemistry 260 (West):

Experimental: The ACS analytical chemistry exam was given as part of the final exam (60% of the overall final exam grade). The average score 16 students was 26.19 (± 5.55) out of 50. This score is 95.2% of the national average 27.5 (± 7.1).

Results and Discussion: These means are not significantly differently at the 95% confidence level. Furthermore, these results are comparable to the averages found over the last several years for this course (see figure below).



Due to time restraints not all of the topics on the exam were explicitly covered in the course.

- <50% on topics not covered: activity coefficients,Charge and mass balances,Standard addition,Retention factor.
- >75% on topics covered:Concentration conversions/dilutions, Acid-base titrations, pH calculations, buffers
- Poorly on chromatography (both GC and HPLC), particularly on using the conceptual relationships between solvent polarity and elution time/order for normal and reverse phase HPLC.

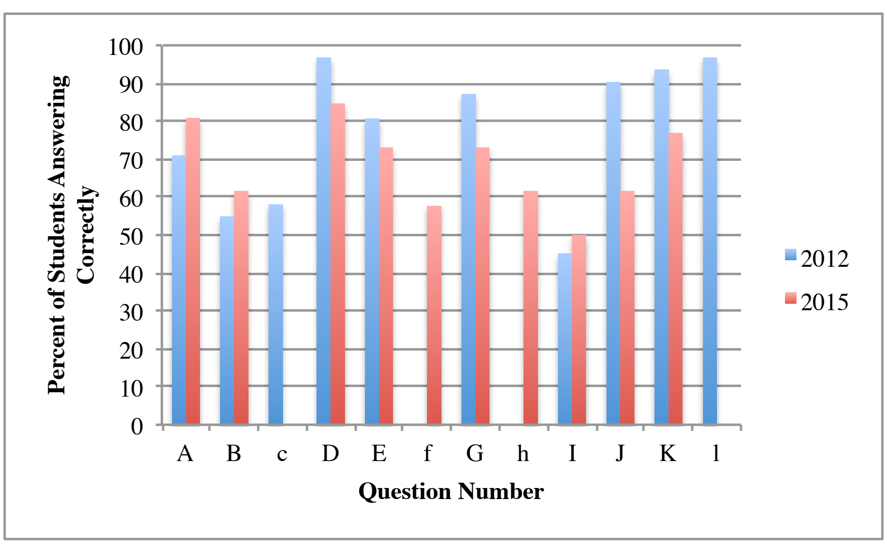
What will be done differently in Chem 260 as a result of what was learned? More diagnostic testing early in the semester will be used to encourage students to review general chemistry topics. This will also free up additional class time to cover topics not covered this semester. More in-class examples and activities, as well as additional laboratory practice to reinforce chromatography principles.

<u>Biochemistry I 350 (Bolitho)</u>

***Experimental**:* Ten multiple choice questions testing foundational knowledge of the structures of nucleic acids, proteins, carbohydrates, and lipid bilayers were embedded into the final exam.

<u>Benchmark</u>: 7 out of 10 questions correct.

Results and Discussion: Of the 26 students, 16 (61%) met or exceeded the benchmark score The average correct



answers was 6.8. Fall 2012 semester, 81% of the class met or exceeded the benchmark with a class average of 7.8

correct responses.

The plot shows that the fall 2015 cohort did less well on questions J & K. Both questions asked students to compare across multiple types of biological macromolecules (i.e., proteins, nucleic acids, carbohydrates, lipid bilayers).

***Conclusions**:* fall 2015 data suggest that both majors and non-majors competed on an even playing field, as they achieved statistically identical results in aggregate.

No solid hypothesis regarding a rationale for this (historically) low performance could be identified. The course textbook, instructor, and structure remained the same. While less material was covered in fall 2015 than in previous years (in the interest of promoting more class participation *via* discussion during the lecture period), the material left out of fall 2015 coverage had almost exclusively to do with proteins and this class performed *better* proteins (questions A & B) this year. Thus, a decreased ability for students to successfully compare / contrast and classify across the four biological macromolecules covered in the course was the primary driver behind the low benchmark attainment.

What will be done differently in Chem 350 as a result of what was learned?

We will either include questions that connect concepts between different macromolecule classes in routine problem sets, or a final assignment at the end of the semester that gives the students more practice with this skill

How the faculty has helped students overcome learning weaknesses and improve their strengths.

- Group problem sets were collected and graded on Canvas so all students received instructor feedback
- Students who performed poorly on tests were extended special invitations to pick up their tests in person and have a discussion to try to identify the root cause of the poor performance (e.g., difficulty with concepts or inadequate study strategy). Students were receptive to this outreach. After a second poor performance, they had to seek individualized advise.
- Groups were intentionally chosen; for example, students who performed well in Analytical Chemistry were divided among different groups for the problem set regarding acids & bases. The expectation here was that all students take on a leadership role at some point based off knowledge acquired in previous courses.

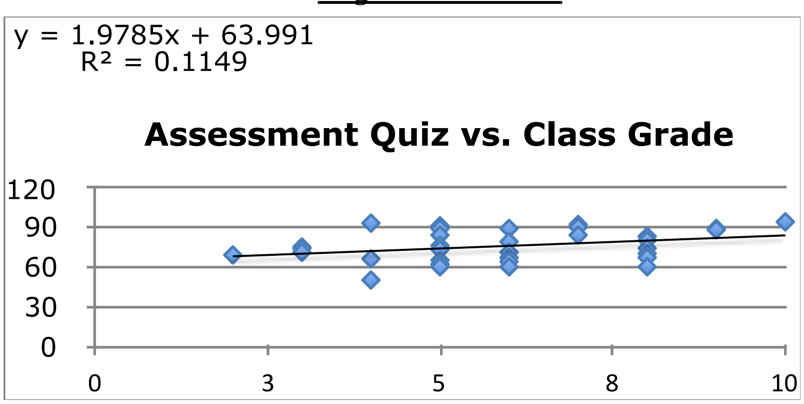
Inorganic 420 Lab (Curtis):

The BS Chem cohort of students (who have taken two semesters of Pchem before taking chem420) came in with a respectable average of 54th percentile on ACS standard exam; not spectacular but not troublesome either. The BS biochem emphasis cohort, on the other hand, turned in average performance of 36th percentile — which means well below-average mastery of the inorganic material relative to national norms.

The primary reason for the lagging performance of the biochem emphasis students in the chem420 course stems from a departmental decision some years ago to alleviate these students the stress of taking Pchem II (the second semester where quantum mechanics and spectroscopy are introduced). In my view, the drive to completely optimize the new track's chances needed to be tempered with some willingness to consider the quality of our entire curriculum by finally launching the much-needed one-semester Pchem course (and then simply make that a pre-req for chem 420 – all problems would thus be addressed without damage accruing anywhere). If, however, the planned degradation of the traditional track goes through regardless, we will then need to stop using the ACS standardized exam as a diagnostic of how we're doing with our students in this discipline and go over to something of lower quality (or simply nothing) so as to conceal the downward shift in learning outcomes/student preparation.

LO#2: Students will recognize and understand the concepts and skills learned in prerequisite courses at or before the start of the new course or laboratory. Aligns with ILO2 and 3 (Students construct, interpret, analyze, and evaluate information…)

Organic Chem 230:



All students enrolled in the course were e-mailed a few weeks prior to the beginning of class outlining aspects of General Chem. II quiz to be administered at the start of class (small amount of extra credit ifs they achieved 70% or higher) and compared to their final grade. One set of class data shown below is typical:

Results

Based on this data we find little correlation between the quiz grade and course performance for most students. Although the intent is to encourage them to re-study General Chem topics before they start the course, the lack of correlation clearly indicates that they do not benefit much (if at all) from this exercise in terms of preparation for learning and excelling in organic chemistry.

What will be done differently in Chem 230 as a result of what was learned? The assessment quiz is not achieving its purpose.

- We will not give this quiz next year and instead analyze the General Chemistry II grades with their Organic Chemistry I grades to see if there is a significant correlation
- best indicators of student performance in organic chemistry is ability to draw organic Lewis structure, analyze qualitative organic acid/base problems and perform simple mechanistic arrow pushing *at the beginning of the first semester.* We will spend the first week of class teaching these basic skills, and then quiz on these skills in the second week. We will access if there is correlative with student achievement at the end of the course.
- Results from the new assessment instrument will allow us to more effectively evaluate if a student should remain in the class. It is best to encourage students who will fail to achieve the minimum grade pre-req. to withdraw from the class as soon as possible and revaluate their educational goal with their academic advisor(s).

Include a discussion of how the faculty has helped students overcome learning weaknesses and improve their strengths.

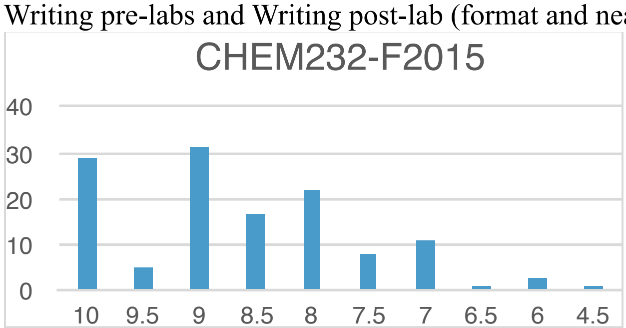
We have improved student's ability to solve spectroscopy problems by introducing dry lab on 1H NMR in Organic Chemistry I lab (Chem. 232). In addition, we introduce IR and 1H NMR spectroscopy much earlier in the semester then suggested by the textbook and once introduced we continuously reintroduce the material in the context of specific functional groups and retest the students on every subsequent exam throughout the year. In addition, we try hard to coordinate the content of the lecture and laboratory courses so that they are mutually reinforcing. Finally, although we encourage all students to attend our office hours and review sessions, we particularly reach out to those who are struggling in our classes.

LO#3: Students or student teams will demonstrate mastery in problem solving by performing a broad variety of analytical, computational and synthetic procedures using proper safety protocols, and will critically evaluate the results…. Aligns with ILO6 (Students use multiple methods of inquiry and research processes…)

Chair summary by course assessment:

Organic Chem 232 Lab: (majors + non-majors lab)

Experimental:At the end of the semester, an individual lab practical was given. The objective of the lab practical is to separate a mixture of an unknown acid and an unknown neutral compound. In a pool of 4 acids and 4 neutral compounds. **Grading/Rubric**: 2 points each = 10 points

- Acid-base extraction (Yields as the criteria);
- Melting point (closeness to literature values as the criteria);
- Taking and interpreting IR spectra (cleanness and interpretation as the criteria);
- Taking and interpreting NMR spectra (cleanness and interpretation as the criteria);
- Writing pre-labs and Writing post-lab (format and neatness).
- 

Results and Discussion Among 128 students who took the lab practical, 23% earned a perfect score of 10/10. The majority of the students scored 7 or up, 73%. Only 5 students (5/128 = 4%) scored at or below the benchmark of 65%. I was personally rather satisfied with how well the lab practical went. The students took it very seriously and most of them did very well. For one 4% students who failed to meet the benchmark, they had too big of the discrepancy between their measured melting points and the literature values. There were two possibilities: one was that the sample itself was not pure enough; two was that the students did not pack the sample tightly and properly.

What will be done differently?

Accordingly, it might be beneficial to have each of the partners switch their responsibilities alternatively for every other experiment. This way, we can ascertain that every student would have an opportunity to practice every techniques that we tach multiple times instead of the more motivated or more aggressive one doing most of the experiments.

Organic Chem 233 Lab: (majors only; Castro)

Experimental: A lab practical was given as the last lab. Instead of being given a new experiment, requiring students to apply skills to a new reaction sequence, this practical focused on reproducibility and the enormous importance of the lab notebook in doing research. To this end, the exam consisted of the each student being assigned a previously run experiment on a slip of paper at the start of the lab. They were allowed only their lab notebooks during the practical. Grading was based on their ability to repeat the experiment, based on what they had written in their lab notebook, making any appropriate modifications. Thus they needed to have made sure they had a detailed procedure, with appropriate observations data analysis to ensure a passing grade.

For the students to achieve a passing grade they needed to obtain at a minimum the same yield (within 5%) of their first attempt. Higher grades were based on yields significantly (> 10%) above the first attempt. The lab, including both experimental aspects and data interpretation, was completed on one 4 hour period and graded out of 100 points

Results and Discussion: There were 8 students in the class, all students worked independently in their own hood. The benchmark was 75%. The raw data for the grades on the lab practical are provided below. The mean was significantly above the benchmark (85%).

Conclusions: Students demonstrated significant experimental competency and collected spectral data within the timeframe without much input from me. All students produced relatively pure solid/crystalline product and collected spectral data without my help. Weaknesses in student learning were more significant in data interpretation, particularly the calculation of overall yield and 1H NMR interpretation.

What will be done differently as a result of what was learned? A greater emphasis could be placed on calculating yields. Students collect spectral data on all synthesized products, but there could be a greater emphasis on accurate NMR interpretation throughout the semester.

Analytical Chem 260 Lab:

Experimental: Students were required to complete a lab practical on the last day of lab (determine the pKa of an unknown weak acid. They were only allowed to use a burette, standard glassware and pipettes, pH paper, and universal indicator. No other instructions were provided. The practical was graded based on:

Did the student correctly carry out a titration?
Did the student correctly calculate the equivalence point?
Did the student perform replicate measurements and calculate uncertainties?
Did the student utilize the relationship pH = pKa at ½ equivalence point?
Was the calculated pKa within 2 units of the actual pKa? What it within 1 unit?

Results and Discussion The overall average on the practical was 76% with a low grade of 0% (did not show up) and a high grade of 110% (extra point were possible for duplicating measurements and presenting uncertainties). Most students (7 of 15) made a 70%.

Conclusions: All students showed competence titrating and most repeated the titration 3-4 times to assess errors. Most presented the half-equivalence point as an average value and an associated standard deviation. Some even performed a Grubbs test to discard an outlier. The largest obstacle for the majority of the class (all but 4) was using the information from the titration to determine the pKa. The most common mistake was to equate the pH at the equivalence point to the pKa. Oddly enough, this was not a common mistake on written exams, where they correctly associated the pKa with the pH at the ½ equivalence point.

What will be done differently as a result of what was learned? Critical thinking and application of concepts learned in class should be emphasized more. Practice and proper guidance, while still allowing decision-making, are needed. This will be accomplished by one or more of the following:

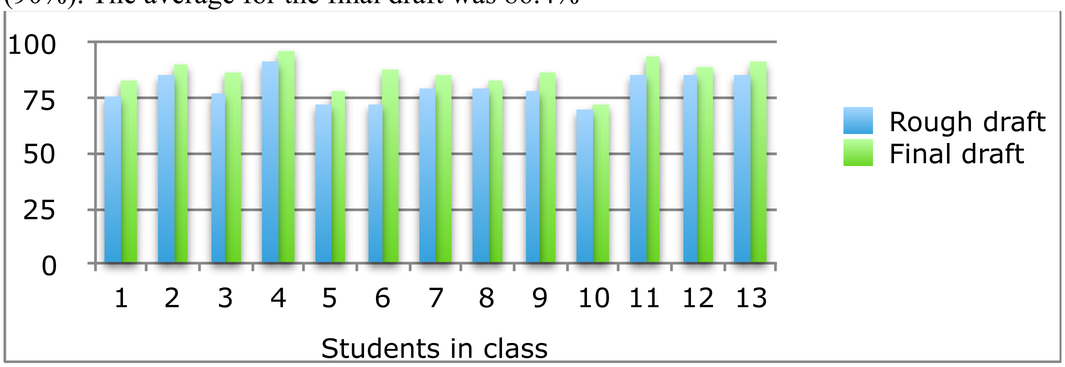
- Adding a mid-term practical
- Providing more opportunity for problem solving in existing/new experiments.
- Incorporating conceptual problems on homework and exams requiring the students to explain how they would plan/execute an experiment to determine an unknown.

LO#4: Students will demonstrate effective scientific communications skills in both written and oral form. Students will be able to write reports and present results while following professional policies regarding intellectual property, plagiarism, and group work. Aligns with ILO 4 (Students communicate effectively in written and oral forms…) and ILO5 (Students use technology to access and communicate information…)

Organic Chem 233 Lab: (majors only; Castro)

Experimental Students wrote a rough and final draft of lab report in the form of a full paper and participated in anonymous guided peer-review using a supplied student worksheet. A rubric was used to grade both the rough and final drafts of the lab reports.

Results and Discussion: The average for the rough draft was 79.8%. The average grade for peer-review was 9.0 (90%). The average for the final draft was 86.4%



Conclusions This is a very effective evaluation of student learning. It should also be noted, that many students did well on their first draft of the paper because a) the first draft was worth more of the total grade for this assignment (this was to encourage to take this draft seriously) and b) throughout the semester they were required to write the separate sections (e.g., Abstract, Introduction, etc.) of a full paper (one section/week) and therefore it wasn't their first time writing each type of section. The primary weakness was the variability in quality of the peer-review assignment. Also, some students are very weak writers and it is difficult to tackle this in a lab course.

What will be done differently as a result of what was learned? Improvement in the method of the peer-review so that it more consistent from student to student. Perhaps streamlining/focusing the assignment more would help. For writing issues we could coordinate/work with the Rhetoric and Composition Department on methods to improve student writing.

Chem 260

Experimental: Lab reports were mandatory for 9 of the experiments. The format of the report varied, including executive summaries, full lab reports, and a 1-paragraph abstract (for the last lab of the year). No revision process or peer-review was implemented. Consequently, the students only guidance for the first report were a list of guidelines and an example report provided by me. This first report served as a measure of their initial competency.

Results and Discussion The scores rapidly increased for almost all students through the first 2-4 assignments, presumably due to direct and indirect feedback. After this rise, the grades leveled off. Some students leveled off in the A range while others leveled off in the B or C range. Continued practice did not lead to further improvements.

What will be done differently as a result of what was learned? In a smaller class, one-on-one discussions about a student's reports could be very valuable and give the student incentive to continue improving. Peer review will also be implemented.

Chem 397 (Spring Li)

Experimental: Three students delivered ~15 minute oral PowerPoint presentations of their independent research projects the ACS Northern California Undergraduate Research Symposium (NCURS). Two faculty members independently performed this assessment. One student delivered a ~15 minute oral PowerPoint presentations of their independent research projects at the USF Creative Activity and Research Day (CARD).

40 points possible	*A*	*B*	*C*	*D**	*Item Mean*
Vocabulary	4	3.5	4	4	3.9
Organization	4	3.5	4	3	3.6
Content	4	3.5	4	4	3.9
Speaks Clearly	3	4	3	4	3.5
Posture & Eye Contact	3	4	4	3	3.5
Used Visual Aids Well	3	4	4	4	3.8
Graphics – Clarity	3	4	3	2.5	3.1
Graphics – Relevance	4	4	4	3.5	3.9
Graphics – Originality	3	3.5	3	4	3.9
Attractiveness	3	3	3	4	3.2
Total	**34**	**37**	**36**	**36**	**36.3**

Conclusions: Overall, our CHEM397 students did a good job. A lesson learned here is that no matter how well the slides are prepared, one has to test them on the computer and project he/she is going to use for the presentation. Students need to assume that most of the audience will not know the minutia of their project and should give a more fundamental explanation when comes to acronyms and basic concepts. Poster presentations are mostly satisfactory because more time was devoted to it by the individual groups and I had a chance to do a final proofreading as well.

What student learning improvement initiatives might you implement in your course as a result of what was learned from this Year's student learning assurance report?

The best way to learn to emulate the best. The intent is that we will invite more outside speakers. Not only did the students learn cutting-edge chemistry, they also might learn what a professional presentation was done. Therefore, it might be helpful if oral presentation opportunities were provided in as many classes as possible, not necessarily just the advanced courses. The "mock" oral presentation has done wonders to the students who never had done a presentation in public. It is highly recommended that we keep giving them more opportunities.

LO#5: Students will apply their experience and knowledge of the discipline in the successful conduct of at least 80 hours of additional work via undergraduate research (Chem 397), Experimental Biochemistry (Chem 352), integrated Lab (Chem 410) or Chemistry Electives courses.

Chair summary:

- Chem 397 Undergraduate research: 9 students F15, 11 students S16.
    - Resulting in about 4-6 hrs/week x 14 weeks = 56 - 84 hrs work for each student (juniors and seniors)

Chem 352 and 410 are only offered every other year (not offered in S16)

Electives:

Chem 310 Kitchen Science 17 students

Chem 311 Environmental Chemistry 8 students

Section IV: Continuous Improvement

Indicate Actions the Program Faculty Have Taken in Response to Results
(Check all that apply)

a. Revision of PLOs: LO#5 was changed in May 2015 to "encourage majors to go beyond the minimum requirements with more in-depth electives, on campus or off campus research, or chemistry related internships".
b. Changes in pedagogical practices: Staged writing of Lab Reports in General and Organic Chemistry is under discussion. Alternate review/prerequisite training will be attempted based on our assessment that the quiz is not working well.
c. Revision of program course sequence: We are adopting our accrediting agency (ACS) guidelines to create different chemistry tracks or emphasis areas (not new major degrees). Each major will be required to take "Foundational" and "In-depth" course work. A new medicinal chemistry track was approved by department vote in spring 2016 with proposed revisions to other foundational courses and in-depth labs to be determined
d. Revision of course(s) content: Ongoing based on assessment results.
e. Changes to faculty and/or staff: Replacement in Biochemistry (Dr. Janet Yang in Fall 2016 1/2 time)
f. Modified course offering schedules: None AY2016-17. Regular 2-year rotation Chem 410 and 352 Labs in Spring 17