Central Washington University

Assessment of Student Learning Outcomes
Degree Program Report

College: COTS | Department: Chemistry
Program: major in Chemistry | Degree: BS in Chemistry (including Biochemistry Specialization)
Prepared by: Robert Rittenhouse | Academic Year of Report: 2014/15

1. What student learning outcomes were assessed this year, and why?

In answering this question, please identify:

- the specific student learning outcomes that were assessed
- reasons for assessing the outcomes, with the outcomes written in clear, measurable terms
- which CWU Strategic Plan Outcome do the student learning outcomes relate to?

For the 2014/15 school year, the chemistry department assessed three of the seven outcomes identified in the department's SLO Assessment Plan for the BS degree:

Outcome #1: "Chemistry majors will master the concepts and skills, including experimental techniques, designated in curriculum learning outcomes for courses in analytical, biochemistry, inorganic, organic, and physical chemistry, which are needed to graduate and successfully pursue career pathways."

Outcome #5: "Chemistry majors will be able to retrieve and critically analyze chemical literature."

Outcome #7: "Chemistry majors will work effectively in group situations."

The outcome #1 is most closely associated with the levels of academic mastery of the chemistry curriculum and technical competence in the laboratory achieved by chemistry majors in the BS degree program. As such it is considered by the department to be an important quality control metric relevant to the preparation of our graduates for the next step in their career pathways, whether that involves graduate school, professional school, or finding suitable employment. On the last page of the BS degree assessment plan the department's 6 year projection of outcomes to be assessed shows that Outcome #1 will be assessed every year.

The outcome #5 is much more specific and is assessed less frequently. Practicing scientists must have the ability to search effectively and retrieve relevant information from the vast resource of published literature. It's important that all chemistry graduates have gained hands-on experience in this process and have demonstrated the capacity to perform a successful literature search.

Outcome #7 is about being able to work effectively as a member of a team to accomplish identified outcomes. Chemistry students commonly work in pairs or larger teams in the laboratory courses, and as members of faculty research groups. They often collaborate to prepare presentations of their research findings.

The chemistry outcome #1 is closely tied to the CWU Strategic Plan Outcome 1.1.1 and also relates to Strategic Plan Outcomes 1.1.2 and 1.1.3. Chemistry outcome #5 is crucial to effective research and scholarship, and therefore supports the Strategic Plan Outcome 3.1.2. Working effectively as a member of a team also contributes to effective research and scholarship, as well as learning outside the classroom. Therefore, chemistry outcome #7 aligns well with both Strategic Plan Outcomes 3.1.2 and 1.1.2.

2. How were the student learning outcomes assessed?

A) What methods were used?

Concisely describe each specific method used in assessing student learning outcomes. For each assessment method specify:

- If that assessment method was direct (e.g. exams) or indirect (e.g. focus groups)
- If the assessment method assessed performance, knowledge, and/or attitudes
- The specific standard of mastery (criterion) against which you will compare your results. For example, "at least 85% of students pass the senior exit exam"

The methods of assessment that were used to determine the extent to which the three outcomes described above were actually achieved in 2014/15 are listed in Table I below, along with the corresponding standards of mastery designated in the BS SLO Assessment Plan, and other requested information.

Table 1

Chemistry BS Outcome Assessed	Method of Assessment	Direct or Indirect	Standard of Mastery	Who was assessed
#1	Mean percentile, by course, for majors taking standardized ACS exams for courses that require them.	Direct	Mean scores (as percentiles), by course, are at or above national averages, i.e. ≥ 50 percentile.	Chemistry BS majors taking courses that require students to take ACS exams.
#1	Percent of majors in required courses receiving a D, F, or W, i.e. not obtaining at least a C- needed to continue to next course.	Direct	The percent of majors in any required course receiving a D, F, or W is less than 20%.	All chemistry BS majors taking any required chemistry course during 2014/15.
#1	Exit survey taken by graduating seniors	Indirect	The mean response to item 2 on the exit survey is at least 4 on the scale of 1 to 5 for both lecture and laboratory courses.	Majors who graduated with the BS in chemistry during 2014/15.

Table 1 (cont'd)

#5	Grades in relevant courses, specifically Chem 488 (Colloquium) and Chem 295/395/495 (Research)	Direct	All majors receive a grade of C+ or better on their oral presentation in Chem 488	Majors who were enrolled in Chem 488 and/or were part of a faculty research group.
#7	Grades in required laboratory courses.	Direct	All majors receive a grade of C+ or better in laboratory courses.	Majors taking required laboratory courses.
#7	Grades in student research (Chem 295/395 /495)	Direct	All majors participating in faculty research groups receive a grade of B or better.	Majors signed up for research credit.
#7	Exit survey taken by graduating seniors	Indirect	(no standard specified in plan)	Majors who graduated with the BS in chemistry during 2014/15.

All of the assessment methods listed above, aside from the exit survey, assess knowledge, including the comprehension of concepts, and the application of knowledge in the performance of skills. The items taken from the exit survey given to graduating seniors, reflects the attitudes of graduates related to their experience in the chemistry BS degree program at CWU.

B) Who was assessed?

- The population assessed
- The number of students assessed (e.g., 53)
- Survey or questionnaire response rate (if appropriate)

Populations of students whose learning was assessed by each method are listed with the method in **Table 1** above. Most of the assessment methods assessed the 94 declared majors in the BS degree program in 2014/15. The items taken from the exit survey assess the learning experience of 18 BS degree graduates in 2014/15.

C) When was it assessed?

- When did the assessment take place (was it at the end of the degree, as students entered the program or during a specific term?)

Assessment data was collected and analyzed at the end of the 2014/15 academic year for the BS students enrolled in one or more terms during the 2014/15 academic year.

3. What was learned?

- Were the standards of mastery met?
- Report results in specific qualitative or quantitative terms, with the results linked to the student learning outcomes you assessed, and compared to the standard of mastery (criterion) you noted above
- Include a concise interpretation or analysis of the results

Assessment results followed by analysis for each of the three outcomes identified above:

I. Assessment results and analysis for Outcome 1

Outcome 1 is concerned with the overall academic performance of majors in the chemistry BS program and their progress through the curriculum.

To provide an external standard for the academic performance of chemistry majors, American Chemical Society (ACS) standardized exams are administered to students in the required courses listed in the table below. The number of majors who took the exam and the mean percentile score (based on national norms) are provided.

Table 1

Course no.	Course title	Number of **majors** taking exam	mean percentile score
Chem 183	General Chemistry III	16	37.6
Chem 332	Quantitative Analysis	30	46.7
Chem 363	Organic Chemistry III	22	*
Chem 381	Physical Chemistry (Thermodynamics)	20	>50**
Chem 432	Biochemistry II	14	7.0
Chem 452	Instrumental Analysis	11	61.3

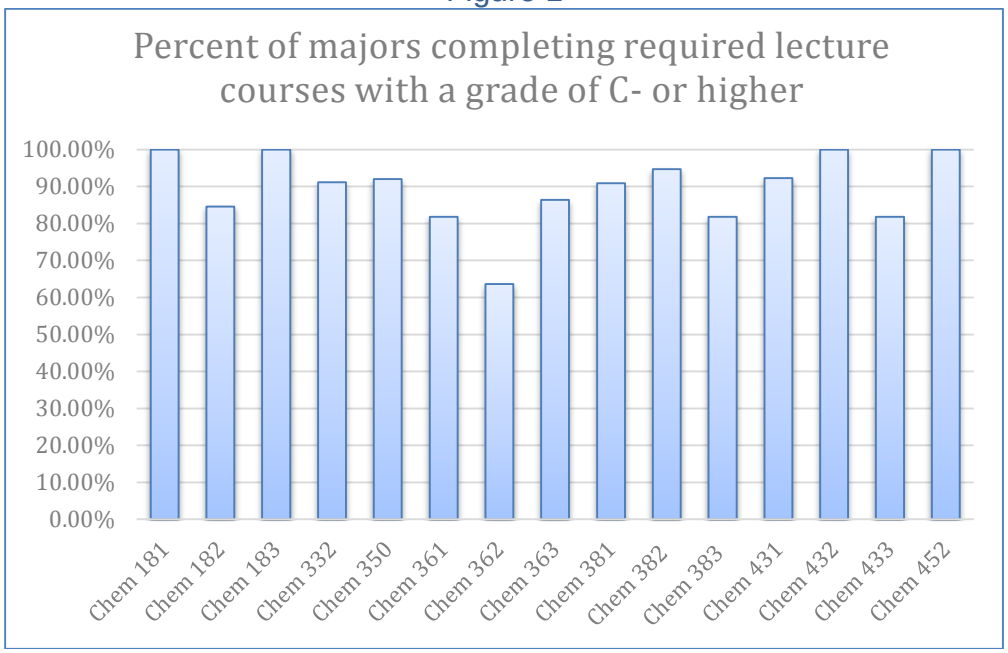
** - ACS exam results not reported by departing Chem 363 instructor*
*** - National norms not yet available for new ACS exam given in Chem 381, however class average percentage, based on raw scores, (31.5%), exceeded current national average percentage (27.2%).*

The standard of mastery specified for this assessment method in the Chemistry SLO assessment plan for the BS degree program states that the mean percentiles for each course, for the majors enrolled in the course, will equal or exceed national averages, i.e. mean percentile $\geq$ 50 percentile. For academic year 2014/15, only two of the six exam distributions met this criterion, Physical Chemistry and Instrumental Analysis. Both of these courses are usually taken by majors in their senior year. The other three courses, for which data is available, fell short of this benchmark. These results are a matter of concern for the chemistry department and we continue to seek to identify causative factors.

A second assessment method looks at the success of chemistry majors as they navigate their way through the array of curriculum requirements for the BS degree toward graduation. For each of the required courses in the BS curriculum, the percentage of majors taking the course during 2014/15 and achieving a grade of C- or higher is plotted in Figure 1. Based on our analysis in last year's SLO report, the standard of mastery was established in the assessment

plan at 80% of majors passing with at least a C- grade. As can be seen from the bar graph, only one course out of 15, Organic Chemistry II, had a success rate for majors that was less than 80% earning a C- or higher.

Figure 1

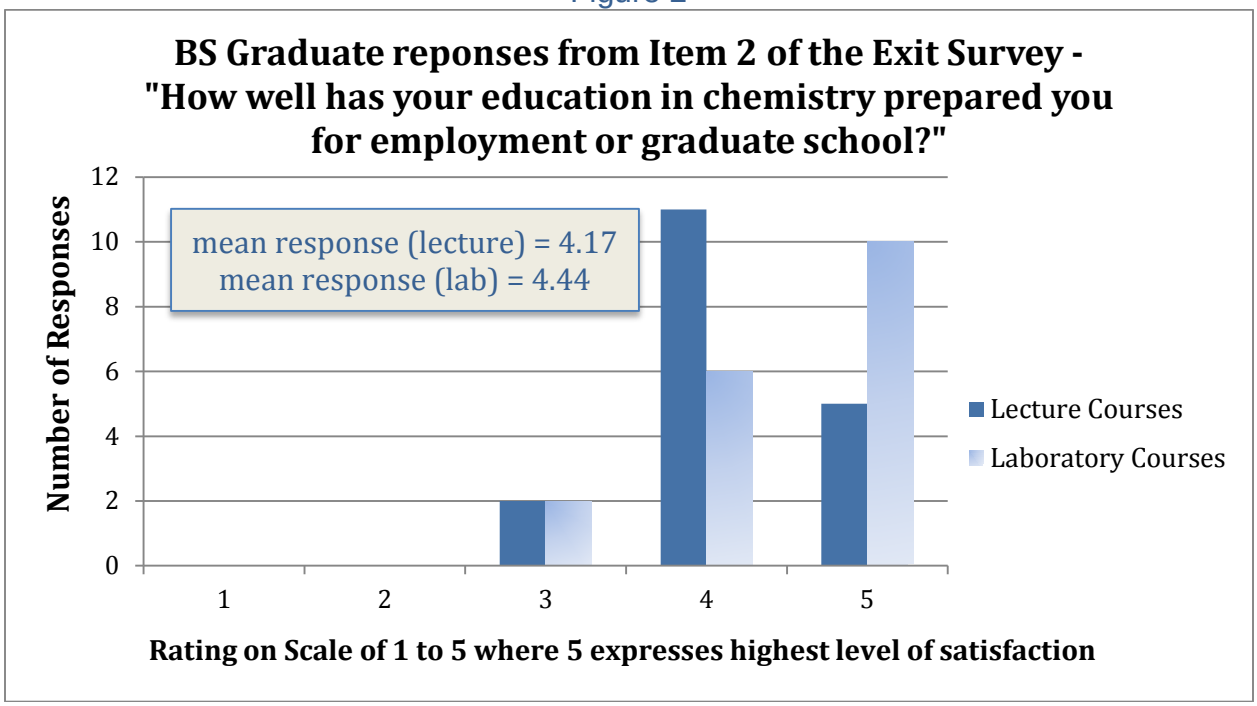


It should be noted that in cases where students took a particular course more than once during 2014/15 due to receiving a D, F, or W, they are counted more than once. For courses with large enrollments of non-majors, e.g. General Chemistry and Organic Chemistry, the percentages of majors succeeding with a grade of C- or better is generally higher than the same measure applied to the non-majors.

The perspective of graduating seniors on the value of their education is important to chemistry faculty and staff. The results from item 2 of the department exit survey given to 18 BS graduates seem to indicate a high level of satisfaction on the part of our graduates that the quality of the lecture and laboratory chemistry courses received at CWU is sufficient to prepare them for future employment or graduate school. The results of the survey and summarized by the bar graph in Figure 2.

The standard of mastery designated in the assessment plan for item 2 of the exit survey is that the mean response is at least 4 on the scale of 1 to 5 for both lecture and laboratory courses. The actual mean responses for item 2 are 4.17 for lecture classes and 4.44 for lab classes. Clearly, the standard of mastery was exceeded for this assessment method.

Figure 2



II. Assessment results and analysis for Outcome 5

Outcome 5 concerns a specific skill set – being able to search for, retrieve, and critically analyze literature in the field of chemistry. The capstone Colloquium course, Chem 488, requires that students search and draw from the chemical literature the resources needed to prepare an oral presentation on a current topic in chemistry. The students present the results of their work to an audience of faculty, staff, and students at the end of the course. The faculty evaluations of the student presentations significantly influence the final grades in Chem 488.

During the 2014/15 academic year, 22 majors took the Colloquium course. The mean GPA for the majors taking the course is 3.65, with 95.5% of the majors passing the course with a C- or higher. The standard of mastery for this assessment method calls for all majors to receive a grade in Chem 488 of C+ or higher. Strictly speaking, this standard was not met, however it was very nearly achieved. Just one student out of 22 failed to achieve at least a C+ for the course.

Though not a required component of the BS curriculum, most chemistry majors take advantage of the opportunity to join the research group of a faculty member and sign up for research credit. The initiation into a research group usually involves time spent getting acquainted with the literature relevant to the research project. 28 majors completed one or more quarters of research during 2014/15, all of whom succeeded in obtaining a grade of B- or higher.

III. Assessment results and analysis for Outcome 7

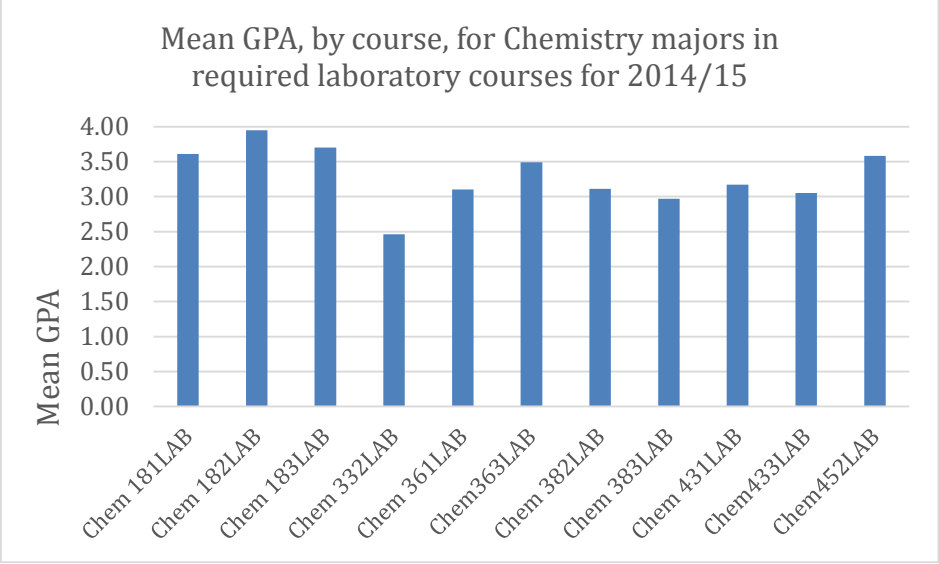
Outcome 7 in the BS assessment plan addresses the ability of chemistry majors to work together in collaboration to solve problems or to achieve some other designated objective. While students are sometimes asked to work together in small groups within the lecture classroom setting, it is the laboratory classes where success in the course is quite dependent on productive collaboration among peers. The BS degree program includes either 10 or 11 lab courses, depending on the specialization. Students signing up for research credit as part of a faculty research group usually receive additional laboratory training with further experience in peer collaboration.

The grades earned by majors enrolled in lab courses are reported in the table and graph below as mean GPA by course.

Table 2

Lab Course	Credits	Number of majors in course	Mean GPA	Standard Deviation
Chem 181LAB	1	10	3.61	0.63
Chem 182LAB	1	13	3.95	0.12
Chem 183LAB	1	14	3.70	0.56
Chem 332LAB	2	36	2.46	1.05
Chem 361LAB	2	26	3.10	1.30
Chem 363LAB	2	21	3.49	0.62
Chem 382LAB	2	19	3.11	0.71
Chem 383LAB	2	10	2.97	0.73
Chem 431LAB	2	22	3.17	0.87
Chem 433LAB	2	11	3.05	0.86
Chem 452LAB	2	13	3.58	0.65

Figure 3

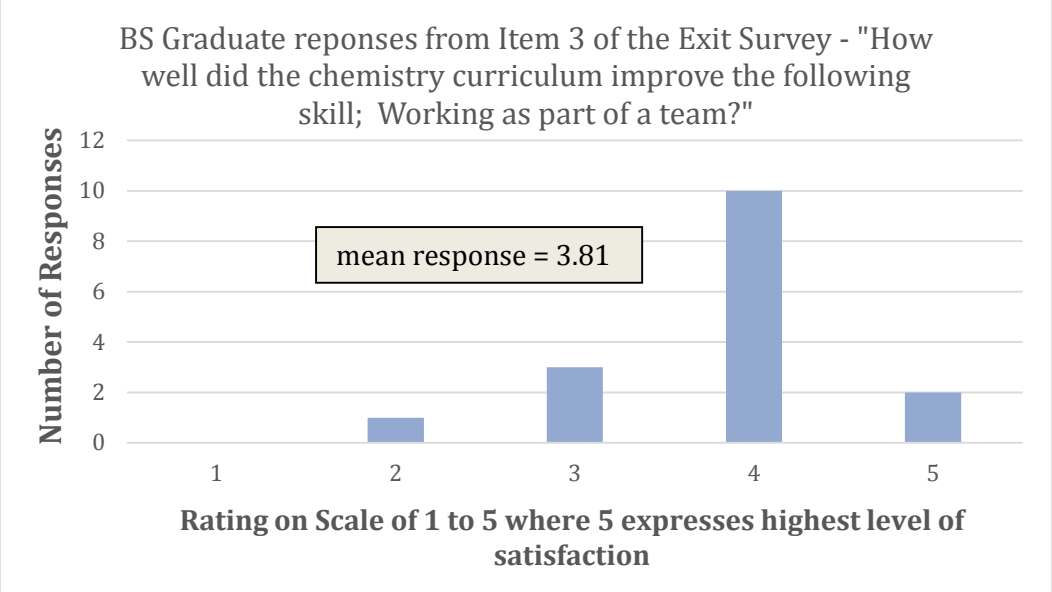


Lab grades do not assess specifically for this outcome in that the ability to work effectively in group situations is only one of several factors that influence grades. The standard of mastery for this assessment method is that "all majors receive a grade of C+ or better in laboratory courses". Though related, a mean GPA doesn't guarantee that every major received at least a C+ in lab courses taken through the year. In cases where the mean minus one standard deviation drops below 2.0, (as in Chem 332LAB and Chem 361LAB), the standard of mastery would certainly not be met.

The ability to work effectively with others in the context of a faculty research group is probably more crucial to success than it is in the instructional laboratory environment. As mentioned in the discussion of outcome 5, there were 28 majors that participated for credit in faculty research groups in 2014/15 for one or more quarters. All of them received grades of B- or better for their contributions to the team effort. The standard of mastery designated for this assessment method requires that all majors doing research receive a grade of B or higher. Since 27 of the 28 research students met this criterion (only 1 student received a B-), the standard was very nearly met.

The results from item 3 of the department Exit Survey completed by 16 BS graduates is summarized on the bar graph below. Although no standard of mastery is currently indicated in the BS assessment plan for the survey results related to outcome 7, the response mean of 3.81 indicates a reasonably high level of satisfaction among graduates that their experience within the chemistry BS curriculum has strengthened their ability to work effectively as part of a team.

Figure 4



4. What will the department or program do as a result of that information?

- Note specific changes to your program as they affect student learning, and as they are related to results from the assessment process
- If no changes are planned, please describe why no changes are needed
- In addition, how has/will the department report the results and changes to internal and/or external constituents (e.g., advisory groups, newsletters, forums, etc.)

Outcomes 1 and 5 are both closely tied to the technical competence of chemistry BS graduates. The standards of mastery for two of the three assessment methods that were applied to outcome 1 were not met. Of concern is the poor performance by CWU students on standardized ACS exams for certain courses where the mean percentile is significantly less than the 50 percentile benchmark. It is important for the department to examine the alignment between programmatic course outcomes and the ACS exam standards for these courses. If there is good agreement, then the exam results, by way of item analysis, should be used to suggest possible changes to instructional strategies.

No program changes are warranted by the assessment results for outcome 5. However, the department should explore the possibility of developing a more specific assessment tool to be used within the Chem 488 Colloquium course to evaluate specific components of the oral presentations related to making effective use of the chemical research literature.

Although working in pairs or small teams in a laboratory setting is a routine part of all chemistry lab courses, the department presently has no assessment method that specifically evaluates student capability and skill in this endeavor. In order to develop assessment methods that are more specific, outcome 7 needs to be defined in more detail. Exactly what does it mean for a student to work effectively in a group situation? What details need to be observed and evaluated? A more explicit definition of this outcome would guide the development of an effective and specific assessment tool. As it is, the lab grades, at best, give us a very rough estimate of the quality of teamwork existing in the department's instructional and research laboratories. The opinions of graduates reflected in the exit survey item 3 seem to indicate a reasonable positive feeling about their experience in this area.

5. What did the department or program do in response to previous years' assessment results, and what was the effect of those changes?

- Describe any changes that have been made to improve student learning based on previous assessment results
- Were those changes effective?
- Discuss any changes to your assessment plan or assessment methods

Over the past year since the last SLO assessment report was submitted, the chemistry department has undertaken three initiatives in response to the previous assessment results.

1. Expand the operation of the Drop-In Help Center and improve the training of tutors.

2. Examine the connectivity between successive courses in the chemistry curriculum to insure that assumptions made in the design of a more advanced course are consistent with what students are taught in prerequisite courses.

3. Take steps to gather and analyze data that allow us to track the progress of every major (and non-major) through chemistry course sequences

For the first endeavor, the department was able to obtain additional financial support needed to extend the operating hours of the Drop-In Help Center, and also increase the number of tutors from 2 to 3 during high demand periods. This expansion has made the free tutoring service offered by the department available to a broader range of students. This fall the weekly training session for the tutors has benefited greater by the involvement of more faculty. Most notably, organic chemist, Dr. JoAnn Peters, has been working with the tutors to review key concepts and skills needed to assist students with questions regarding organic chemistry homework and preparation for quizzes and exams. The number of organic chemistry students using the Help Center has climbed significantly as a result.

The second endeavor is an ambitious project due to the extensive content covered in chemistry courses and the challenge of identifying assumptions related to content that are taught in previous courses. One might think that the necessary connectivity was put in place in the initial design of the curriculum. However, the discipline of chemistry is not static, and course content evolves over time. It's important to recheck assumptions periodically. The motivation is simply to better serve our students by making sure they are not the victim of unintended missing links in the progression of ideas as they progress from course to course. Early discussions are centered around the General Chemistry content (concepts and skills) that are assumed in the Organic Chemistry and Quantitative Analysis courses.

The third endeavor is an effort to better understand the reasons for lack of success in chemistry courses, particular in the large enrollment 3-quarter sequences like General Chemistry, Organic Chemistry, and Introduction to Chemistry. We have developed methods to collect and analyze data needed to track the progress of every student from course to course to see what happens to students who (a) succeed with the C- or higher needed to continue, or (b) fail to achieve the C- threshold of success. Of the students that pass, how many actually continue on to the next course in the sequence? Of the students that fail, how many repeat the course, and for those who repeat the course, how many succeed on their second try (or third, etc.)? We are also able to provide course instructors, if they so desire, a list of the students enrolled in a course that are repeating the course, along with the number of times they've taken the course previously and with what results. This information identifies these students as being at risk right at the beginning of the quarter. Some faculty see this as an opportunity to intervene constructively to assist such students toward a successful experience. Improved retention of students is an anticipated byproduct of such efforts.

Graphical summaries of the results of tracking the students who failed to achieve at least a C- in the first quarter of the General Chemistry and Organic Chemistry sequences during fall quarter 2014 are shown below in Figures 5 and 6. The graphs show the percentages of fall DFW's who repeated the course during the winter 2015 and/or spring 2015, and what percentage of the repeaters passed the course on the second (or third) attempt. The fraction of students who ultimately succeed is significant higher that the fraction that succeed on the first try, especially in the upper division Organic Chemistry course.

Figure 5

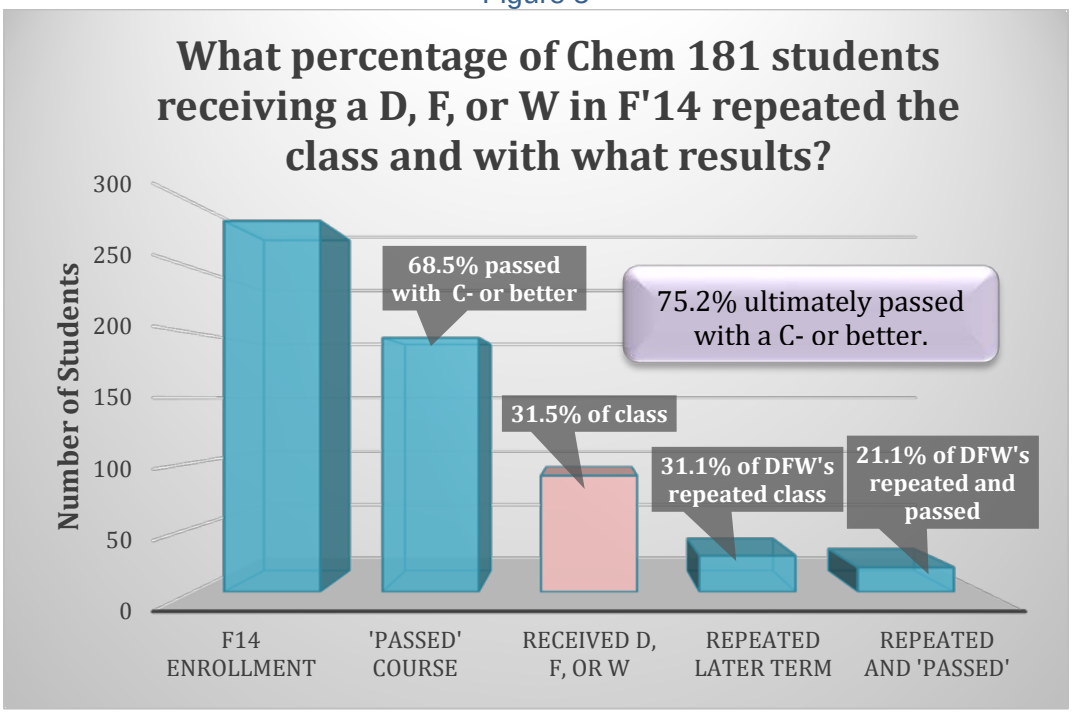
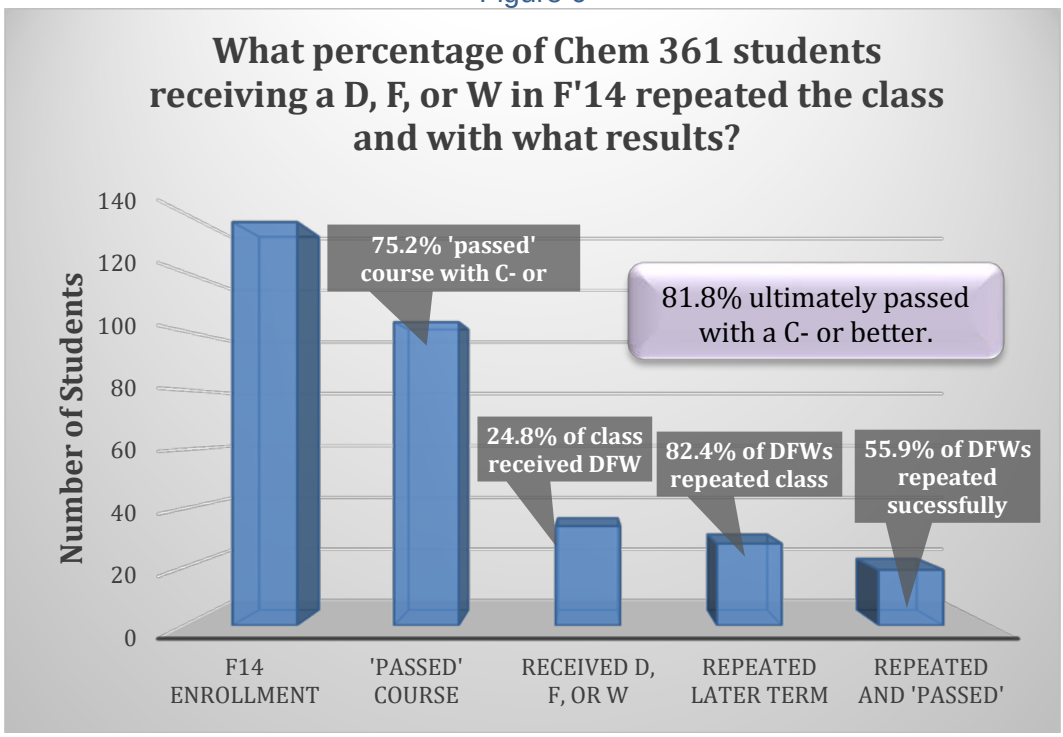


Figure 6



6. Questions or suggestions? Contact Tom Henderson (henderst@cwu.edu) or Bret Smith (bpsmith@cwu.edu)

The current Chemistry department assessment coordinator appreciates the helpful feedback received from assessment guru Bret Smith regarding the department's SLO assessment plan. We realize the need to broaden the SLO outcomes to assess other desirable characteristics of our BS graduates in addition to various aspects of technical competence. We will certainly be seeking advice as we move in this direction.