Chemistry Program Assessment Report October 2018

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I. Profile

a) Chemistry Mission Statement and program goals.

The department’s mission statement is as follows:

The UWRF Chemistry and Biotechnology Department faculty and staff strive to provide students with foundational knowledge of chemical concepts and laboratory techniques, with opportunities for in-depth studies, hands-on use of instrumentation, and research experiences. The program also promotes the development of the core skills of critical thinking, problem solving, oral and visual communication, information retrieval and management, group work, ethics, and safety.

In addition to our mission statement, the department has adopted the following program goals:

- UWRF Chemistry degree recipients shall meet or exceed the standards in Student Content Knowledge expected by the American Chemical Society Committee on Professional Training (ACS-CPT).
- UWRF Chemistry degree recipients shall meet or exceed the standards in Student Professional Skills expected by the ACS-CPT.
- The UWRF Chemistry and Biotechnology Department shall maintain program faculty, staff, and budget which meet national standards as outlined by the ACS-CPT.
- The UWRF Chemistry and Biotechnology Department shall maintain infrastructure which meets national standards as outlined by the ACS-CPT.
- The UWRF Chemistry and Biotechnology Department shall work to implement institutional goals, including the University’s Mission, Vision, Strategic Plan, and General Education.

b) Factors affecting assessment and learning.

Chemistry is a laboratory science, and the Chemistry faculty believe in pedagogies of engagement. It is important that students have access both to modern equipment and to faculty mentors.

The major factors affecting assessment and learning in the Chemistry program include:

- **Resources and infrastructure.** Chemistry, as a hands-on laboratory science, is highly dependent upon institutional resources. At our last review, the deterioration of our instrumentation was a critical need for the department. Positive developments since the last review include:
  - Acquisition of an inert atmosphere glovebox. The lack of the capability to perform chemistry in the absence of water and oxygen has always been a major limitation of our department.
  - Acquisition of a new 96 plate well reader. This instrument is being utilized in our biochemistry laboratory and in student research.
  - Acquisition of a new UV/Vis spectrometer, expanding our student capacity in upper-level courses including analytical chemistry.
  - Acquisition of a preparative HPLC (High-Performance Liquid Chromatography) instrument, used by Matt O’Reilly in his research.
• Acquisition of a ball mill, to be used by Rebecca Haley in her research.
• Tentative approval of funding for a used Liquid Chromatograph – Mass Spectrometer (LC-MS), in the upcoming funding cycle. A mass spectrometer is a critical piece of equipment required by the American Chemical Society (ACS) for program approval.
• Renovation of one of our general chemistry laboratories (CSH 266) as an active learning laboratory and classroom. We are using this room to pilot new instructional methods in anticipation of the construction of the proposed Science and Technology Center.

In its 2018 external review of our program (appended to this report), the ACS-CPT stated, “The extensive improvements to the infrastructure and curriculum demonstrates the level of administrative support given to the department.”

Program challenges related to resources and infrastructure include
• Continued deterioration of current instrumentation.
• Increasingly limited staff time for infrastructure maintenance.
• The push of more infrastructure costs (including distilled water and safety inspections) from central university resources onto the department, stressing the department’s supply and equipment budget.

• **Faculty Load.** The top suggestion from our 2013 American Chemical Society (ACS) external review stated

“…the teaching contact hours per week are in compliance with the ACS Guidelines but are at the maximum level for almost all chemistry faculty. The Committee encourages you to discuss this situation with the administration and identify mechanisms to reduce faculty contact hours in order to improve support for research opportunities with students.”

This was echoed again in our 2018 review, which states,

“According to your report, the teaching contact hours are very close to the maximum allowed in the ACS Guidelines. Please remember that faculty members may not exceed the maximum contact hours specified in the guidelines in order to allow time for curriculum and professional development activities.”

This situation has not been rectified. This semester, several faculty are on overload due to coverage of maternity leave and inability to find qualified IAS to fill instructional requirements, putting us in violation of maximum teaching load allowed by the ACS Guidelines.
• **Grant support.** UWRF received a National Science Foundation STEP (STEM Talent Enhancement Program) grant for $894,000 in Fall 2013. Chemistry faculty members Michael Kahlow and Jamie Schneider are co-PI’s on grant to increase STEM student retention. We have already seen a positive impact on Chemistry student learning (as measured by course GPA) due to the impact of this grant.

Jamie Schneider received NSF support for her chemistry education research program which also provides research opportunities, often for chemistry education students, and provides general chemistry students practice exam experiences. While these grants provide great benefit to our department and students, they also provide some additional stressors on teaching personnel in that the faculty often have teaching reassignments associated with these large nationally funded grants.

• **Faculty staffing.** This has been perhaps the greatest challenge to the department. In 2011 the department had 14 tenure lines and approximately 2 FTE IAS. Since then we have lost five faculty due to retirement (Magdalena Pala, David Rainville, David Rusterholz, Marilyn Duerst, and Jeff Rosenthal) and another two to competitive hires from other institutions (Elodie Marlier and Stacey Stoffregen). In the past four years we have made three new hires (Sam Alvarado, Matt O'Reilly, and Rebecca Haley).

At this same time, demand for Chemistry courses at the 100 and 200 level has increased. In Fall 2014, enrollment in general chemistry courses (CHEM 120, 121, and 115) was 364 students distributed over 6 sections. In Fall 2018, we still have six sections (now CHEM 111 and 115), but with total enrollment of 442 students – an increase in average class size of 21%. Our total introductory (first two year) course enrollment (CHEM 111, 112, 115, 120/121/122, 133, 230, 231/232, and 240) has gone from an average of 700 students per semester (Fall 2010 – 2016 average) to 818 students in Fall 2018.

![Introductory course enrollment since 2013 (Fall only). The major driver for increased demand is the increasing number of students in CAFES who require the department’s courses.](image)

Figure 1.
The net effect is that we have lost nearly half our faculty from 2011 (6 of 14) and have dropped 3 tenured and tenure-track faculty at a time when our introductory course enrollment has increased by approximately 20%.

At the same time, faculty responsibilities, both reimbursed and unreimbursed, have increased, including:
- Chair responsibilities – Peterson (Chemistry and Biotechnology) and Kahlow (History and Philosophy).
- Peer-Led Team Learning (PLTL) coordination reassignment – Kroutil.
- NSF grant supervision reassignment – Kahlow and Schneider.
- UW System Math Initiative reassignment – Schneider.
- Biotechnology coordinator reassignment – Jilk.
- Near continuous departmental and university search activities, in 2013-14, 2016-17, and 2017-18 (resulting in the hires of Sam Alvarado, Matt O’Reilly, and Rebecca Haley), along with a failed search in 2017-18 for a Visiting Assistant Professor.

This turnover and reduction in staff is a challenge to the department:
- Scheduling has become more difficult.
- More administrative and unreimbursed departmental work, including but not limited to advising, student research supervision, assessment, recruitment, curriculum development, laboratory manual development, laboratory safety, instrument maintenance and repair, and website development, falls on a fewer number of faculty. We need to be careful not to push too much of these service activities onto junior faculty, but senior faculty only have so many hours in the day.
- As laboratories are taught more and more by IAS, we have had to revise our laboratory exercises and courses to make them more “plug and play” – to be sure that any exercise is teachable by someone who has little to no experience with that exercise. In the past, a new adjunct or even tenure hire might be teaching alongside one to two experienced instructors, who they could look to for guidance. This is no longer the case.

That the department has continued to stay current, to innovate, and to maintain an excellent program under these conditions is a credit to the department’s faculty and staff.

As for other factors, internally, the decrease in the number of Biology Biomedical students has decreased demand for our Organic First sequence (Chem 130/233/240), while the increased enrollment in CAFES majors has increased demand for our General and Organic Chemistry science (CHEM 111/112/120/121/122, 231/232) and non-science (CHEM 115/230) courses. Externally, the market for Chemistry majors has been stable to increasing, the number of Chemistry majors at UWRF has been slowly decreasing, along with students in upper-level Chemistry courses.
II. **Assessment Activities in Report Cycle**

**a) Prior external program accreditation.**

In our 2013 ACS-CPT review, the committee commended the department on use of open-ended, project-based experiences for students and the dedicated safety course. The committee also praised the department’s extensive use of self-evaluation activities and ensuing modifications to the curriculum.

The committee cited areas of concerns including the teaching contact hours which are at the maximum level for almost all chemistry faculty (in part due to the 2/3 credit count for lab courses), the lack of faculty taking sabbaticals, deteriorating instrumentation, fairly traditional Analytical Chemistry laboratory experience, concerns about the development of a new foundational Inorganic Chemistry course, and concerns about student chemical literature skill development. Several actions were taking during in the current assessment period, including

- Sabbaticals by Jamie Schneider and Barb Nielsen. Dr. Nielsen’s sabbatical was expressly to develop a new Analytical Chemistry laboratory curriculum.
- A new foundational Inorganic Chemistry course, CHEM 322 (lecture) and 325 (lab) has been developed, and is now taught on a regular basis.
- Literature skill development has become a more important part of our Chemistry research course, CHEM 495.
- The department, with the help of administration, has engaged in an effort to upgrade instrumentation.

In its most recent 2018 report, the committee commended our program’s quality and grant funding as praiseworthy, and noted the level of administrative support for the department. It also commended our Polymer Chemistry course and Biochemistry content. Concerns included teaching content hours (again), student skills (lack of formal ethics training), and student research reports.

**b) Dates of assessment cycle.**

This report covers the timeframe from Fall 2015 to the end of Spring 2018.

**c) Statement of Program Learning Outcomes.**

Our Learning Outcomes (LOs) are based upon the expectations of our external stakeholders, notably the American Chemical Society Committee on Professional Training (ACS-CPT), as well as graduate schools and pre-professional schools (including but not limited to medical, veterinary, and pharmacy programs). Our LOs are adapted from the ACS Anchoring Concept Content Map (ACCM)1 and the ACS-CPT document *ACS Guidelines for Bachelor’s Degree*

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1 See for example:
Programs (aka the Guidelines)\(^2\) and its associated supplements. The learning outcomes for the Chemistry program are divided into Content Knowledge Learning Outcomes and Professional Skills Learning Outcomes.

The national Chemistry curriculum is fairly well defined. The standard includes the following foundational coursework:

- Two semesters of General Chemistry
- Two semesters of Organic Chemistry
- At least one semester of Physical Chemistry, which requires prerequisites of Calculus and Physics
- At least one semester of Analytical Chemistry
- At least one semester of Inorganic Chemistry
- At least one semester of Biochemistry, which requires a prerequisite of at least one semester of Organic Chemistry

In addition, the ACS expects that the curriculum for certified graduates includes a) a minimum of 12 semester hours of in-depth work building upon the foundational courses and b) at least 400 hours of laboratory experience beyond the general chemistry level.

Each of these courses includes expectations for content (see https://www.acs.org/content/acs/en/about/governance/committees/training/acs-guidelines-supplements.html for a link to the supplements outlining the expectations for these subdisciplines). Standardized exams are available for each of these courses. These expectations enforce a national uniformity of textbooks, course content, and learning objectives, so that, for example, a 200-level Analytical Chemistry course is fairly similar across institutions.

Stakeholders both inside the field of Chemistry (the ACS and graduate schools) and outside of the field (employers, professional schools) expect that our courses and curriculum will meet these national expectations.

I. Content Knowledge Learning Objectives.

Mirroring the ACS Anchoring Concept Map, the UWRF Chemistry and Biotechnology Department expects that UWRF Chemistry graduates will be able to:

1. describe matter in terms of atoms that have internal structures that dictate their chemical and physical behavior (Big Idea I – Atoms).

2. explain chemical bonds in terms of atoms interacting via electrostatic forces (II – Bonding).
3. connect chemical and physical behaviors with chemical compound geometric structure (III – Structure and Function).
4. compare and contrast intermolecular forces – electrostatic forces between molecules – and apply these forces to explain chemical and physical properties (IV – Intermolecular Forces).
5. predict and analyze how matter changes, forming products that have new chemical and physical properties (V – Reactions).
6. articulate that energy is the key currency of chemical reactions in molecular-scale systems as well as macroscopic systems (VI – Energy and Thermodynamics).
7. interpret and describe chemical changes as it relates to time scale over which they occur (VII – Kinetics).
8. describe how all chemical changes are, in principle, reversible and that chemical processes often reach a state of dynamic equilibrium (VIII – Equilibrium).
9. design and interpret experiments and experimental results (IX – Experiments, Measurement, and Data).
10. construct meaning by visualizing chemistry at the symbolic, particulate, and macroscopic levels (X – Visualization).

II. Professional Skills Learning Objectives.

The ACS Guidelines state that:

“While formal course work provides students with an education in chemical concepts and training in laboratory practices, students should go beyond course content alone to be effective and productive scientists. They need to master a variety of skills that will allow them to become successful professionals.”

The Guidelines require, and the UWRF Chemistry and Biotechnology Department expects, that UWRF Chemistry graduates will be able to:

1. define problems clearly, develop testable hypotheses, recognize chemical hazards, assess the risk of these hazards, design or modify laboratory procedures to minimize risk, and prepare for possible emergency situations. (Laboratory Safety Skills)
2. present information in a clear, organized, and technically appropriate manner. (Communication Skills)
3. retrieve and evaluate information efficiently and effectively (Chemical Literature and Information Management Skills)
4. work with others in a multidisciplinary team to solve scientific problems (Team Skills)
5. responsibly treat data and the citation of the work of others, and understand the role of Chemistry in contemporary societal issues, including areas such as sustainability and green chemistry (Ethics)

Although our Assessment Plan has not yet been formally changed to include these items, we are required to document them for our ACS reviews. Our map of Assessment Artifacts and Venues will be updated to accommodate these items.
d) Engagement with internal stakeholders during the report cycle.
The Chemistry and Biotechnology Department has been in continuous conversations with internal (UWRF) stakeholders during the past decade. Over the past two assessment cycles, we have worked extensively with CAFES to modify our curriculum to meet their students’ needs, notably in the development of a stand-alone nonmajor General-Organic-Biochemistry (GOB) sequence consisting of CHEM 115, 215, 230, and AGBI 251, and in allowing a direct path to biochemistry for students who receive a B- or better in Organic I to accommodate preveterinary students. We have also worked with CEPS to revisit the Broad Field Science options and our role in that curriculum.

e) Engagement with external stakeholders during the report cycle.
Other engagement beyond those with our ACS-CPT include:

- Working with other faculty and departments in the state to attempt to influence licensure changes in secondary education science requirements.
- Working with neighboring graduate and professional schools on development of pre-professional course plans for our students, predominantly relating to our Organic First curriculum. Nearly all medical schools have been accepting of this change. However, we have found most veterinary schools to be incredibly pedantic in their enforcement of a “two semesters of General Chemistry” requirement, to the point where they have required our graduating students to take a second semester of General Chemistry their senior year despite the fact that 1) our students already have that content knowledge in greater depth and breadth in our 200- and 300-level courses and 2) they have taken (and excelled at) the same standardized final exam in CHEM 240 as is used for gen chem II.
- We continue affiliation agreements with
  - Northeastern Wisconsin Technical College, where we have an articulation agreement for their students to enter our Chemistry and Biotechnology programs;
  - Lake Erie College of Osteopathic Medicine (LECOM) where UWRF students can be pre-admitted to LECOM programs in Medicine, Dentistry, and Pharmacy, and
  - Chemical engineering programs.

In addition, we continue with our Family Day activities (our alumni day), we continue to engage with local businesses including Interfacial Dynamics and Fiberstar, and our faculty present at regional and national conferences. All of this provides us opportunities for informal assessment of our program.

f) Assessment activities related to out-of-classroom learning.
The Chemistry and Biotechnology Department is dedicated to pedagogies of engagement. We strive to implement and maintain a curriculum which emphasizes active learning and inquiry, where students have hands-on experience with solving open-ended problems. We take seriously the ACS requirement that our students master not only course content skills, but a variety of professional skills including critical thinking, communication, ethics, and teamwork. These skills
learned, associated with “out-of-classroom learning”, are covered under the ACS-CPT Professional Skills requirements.

Out-of-classroom activities commonly utilized by Chemistry students include

- Undergraduate research, both in the department and in summer appointments at other universities.
- Leaders for Peer-Led Team Learning (PLTL) and Learning Assistant (LA) programs, where they are trained to help other students learn not only content skills but also necessary study and coping strategies.
- Stockroom assistants. Students who are stockroom assistants are paid student assistants who help to prepare materials and facilities for laboratory exercises.
- Chemistry Club, a group of chemistry students who meet regularly and sponsor several events during the year, including social events and visits to career fairs.
- Chem Demons, a group of students who develop and present shows demonstrating various chemical reactions.

Research and internship opportunities are documented through written papers. This assessment has become more rigorous as a result of ACS-CPT suggestions that our student reports were too cursory. Another action taken to address this concern was an increase in the number of credits of research a student was allowed to take during any semester. Students taking a single credit of research were often only working 2-5 hours per week on their project, and we could not expect an extensive report with this little work. It is our hope that as 2-3 credits per semester becomes the norm, that student involvement in research will increase (along with the quality of their reports).

The PLTL program has been assessed through a survey of students participating in the program, and informally through weekly meetings of the peer leaders (who discuss what methods worked and/or are likely to work in the past week, and approaches for the upcoming week’s activities).

**g) Changes to learning outcomes, assessment methods, and curriculum.**

**Changes to learning outcomes.**

Our learning outcomes have not changed during the current assessment period. However, prior learning outcomes, both internal and external, were based upon content areas rather than the ACCM. Standardized exams and textbooks are slowly evolving to be more closely tied to the core concepts, but this process is not complete. As a result, we are flexible in our evaluation of assessment results which combine a mixture of old and new learning outcomes.

**Changes in assessment methods.**

Program assessment methods are most closely tied to ACS requirements and to student success (grades received, retention in the major and at UWRF, and progression within the major). Content knowledge assessment includes:

- Use of full year ACS General Chemistry exam in CHEM 112 and 240.
- Full year ACS exam in CHEM 232 and CHEM 233 (organic chemistry).
- ACS standardized exam in Analytical Chemistry (CHEM 250).
- Pre-course assessment in biochemistry using the Biochemistry Threshold Exam (CHEM 360 and 361).
- ACS standardized exam in Biochemistry (CHEM 362).
- DUCK (Diagnostic of Undergraduate Chemistry Knowledge) exam for graduating seniors as part of the capstone CHEM 480 course.
- Utilization of a structure-function survey as a pre- and post-test in General Chemistry, Organic Chemistry, and Biochemistry.

Changes in curriculum.
The Chemistry and Biotechnology Department prides itself on not only evaluation of its programs, but on making changes based upon the results – closing the assessment loop. As the result of input and opportunities from internal and external stakeholders, the following changes have been made in our curriculum during this assessment period:

- Elimination of CHEM 101 (Elementary Principles of Chemistry). This course was directed towards non-science education majors. It was eliminated, not as the result of low demand, but because of the decrease in staffing during this period.
- Introduction of a new introductory General-Organic-Biochemistry (GOB) sequence for the majority of CAFES students. To satisfy the needs of other programs (primarily in CAFES), the program introduced a new introductory sequence, CHEM 115 and 215 (Concepts in General Chemistry and Chemistry Laboratory – Concepts and Techniques). Along with CHEM 230 and AGBI 252, they make up a General-Organic-Biochemistry (GOB) non-science majors sequence for students who need chemistry for their majors, but not at the level required for fields such as chemistry, geology, or biology.
- Changes in General Chemistry. We have revised many of our laboratories to have a more consistent framework. New exercises have been introduced to emphasize evidence-based reasoning. The major structural changes have been a) splitting off the CAFES programs which don’t require this level of chemistry rigor into our GOB sequence and b) separating the laboratory and lecture portions of the course. The lecture and laboratory were originally integrated into CHEM 121 and 122 in an attempt to increase student success through a cohort effect (the same students would be in the same classes) and to give them the same instructor. Due to increasing lecture sizes, this arrangement became unmanageable. We have again separated the lecture and laboratory (first semester, CHEM 111/116; second semester, CHEM 112/117). In order to make the experience more coherent, lecture instructors are now working together on common lecture schedule and common exams. Other changes to the general chemistry curriculum include the introduction of peer instruction, through Peer-Led Team Learning (PLTL) and Learning Assistants (LA). Each of these programs have been shown to be best practices to encourage student learning and student success.
- Changes in Organic Chemistry. Review of assessment results (Section III) identified areas where students were having difficulty meeting learning objectives. Department
faculty have worked, through the NSF-STEP award, to develop new strategies and/or curricular materials to improve performance. These include
- Sam Alvarado – Kinetics
- Karl Peterson – Nomenclature
- Stacey Stoffregen – Stereochemistry
- Matt O’Reilly – Acid/base chemistry
- Dan Marchand – Chemical mechanisms

- Changes in Analytical Chemistry, CHEM 250. Our 2013 ACS review concluded that the laboratory component of the course was “very traditional”. The review suggested the faculty review the course with the goal of modernizing the laboratory experience. In spring 2015, Barb Nielsen was awarded a sabbatical with the purpose of this laboratory redesign. Dr. Nielsen had two research students piloting laboratory revisions she designed during the sabbatical. Changes to the course have been implemented in this assessment cycle.

- Development of a 300-level inorganic chemistry course. Our 2013 ACS review highlighted concerns with our inorganic chemistry curriculum. To address these concerns the department abolished the then 400-level Advanced Inorganic Chemistry I (CHEM 422) and Advanced Lab I (CHEM 401) courses and developed CHEM 322 (Inorganic Chemistry) and CHEM 325 (Inorganic Chemistry Lab). These courses, developed by Sam Alvarado, have been taught for the first time during this assessment cycle.

- Requirement of both physical chemistry courses, CHEM 341 (Chemical Thermodynamics and Kinetics) and CHEM 342 (Molecular Structure and Spectroscopy) for the major. Prior to this year, students were required to take only one of these courses; the other was an elective. Review of the capstone DUCK results showed that our students were below national averages on their knowledge of physical chemistry content. To fix this situation, the department decided to require both physical chemistry courses for our Chemistry major. (Students with a Biochemistry emphasis are still only required to take one semester of physical chemistry.)

- Introduction of a physical chemistry laboratory. Prior to 2014, inorganic and physical chemistry laboratory were taught in CHEM 401 and 402 (Advanced Chemistry Lab I and II). To address concerns relating to physical chemistry laboratory, the department has introduced CHEM 345, Physical Chemistry Lab. We are planning on teaching this course for the first time in Spring 2019.

- Integration of the Biotechnology program into the Chemistry department. In 2014, the Chemistry Department took over administration of the interdisciplinary Biotechnology program. This has led to a number of changes in the Chemistry curriculum, to implement savings through synergies between the Chemistry and Biotechnology programs.

- Introduction of CHEM 380: Junior Chemistry Seminar. Review of assessment results from senior seminars (CHEM 480) and our 2013 ACS review suggested that students should have additional preparation for this class. The result was the introduction of CHEM 380. This course is integrated with the Biotechnology junior seminar, BIOT 380.

- Changes in the number of credits in CHEM 495 (Undergraduate Research). As stated previously, one concern in our external review was the quality of the papers submitted by
our students as part of their undergraduate research experience. To address this concern, the department has adopted more uniform standards on expectations for research papers, and has increased the number of research credits a student may register for in any given semester.

**h) Changes in Learning Outcomes linked to UWRF strategic goals.**
We have changed our LOs over the report period to more closely match the demands of our external stakeholders (primarily the American Chemical Society).

These LOs meet national expectations as expressed by the American Chemical Society. As such they are directly related to the strategic goal of Distinctive Academic Excellence. They also relate to the strategic goal of Innovation and Partnerships, as external stakeholders (such as professional and graduate schools) know that our students meet the expectations of the American Chemical Society in both their degrees and their course content.

**i) Status of action plans identified in prior assessment report.**
Actions identified in our 2013 Assessment Report include:

- Teaching load. This situation has gotten worse as class sizes have increased.
- Instrumentation needs. This has been somewhat ameliorated by recent acquisitions, as described previously.
- Refining our assessment process. As we have gone through this assessment cycle, we have evaluated our results and made several changes to our courses and curriculum. We continue to evaluate our assessment methods, our assessment results, and look for ways to improve.
III. Assessment Activity Results and Action Plan

a) Direct assessment results and findings, including trend data and meaning of findings to the program.

The current Chemistry program learning objectives (artifacts and venues) grid is included in Table 1.

The Chemistry and Biotechnology Department considers assessment, evaluation, and continuous improvement to be a critical part of our activities. Our hiring of a Chemical Education specialist and our numerous internal assessment activities and curricular changes – our closing of the assessment loop – illustrate this commitment.

Many of the assessment tools we use are only indirectly mapped to our learning objectives (for example, standardized exam items and the Biochemistry Threshold exam). For example, the Biochemistry Threshold exam identifies learning objectives such as “pH” or “hydrogen bonding”; topics in the Diagnostic of Undergraduate Content Knowledge (DUCK) correspond to specific courses in the curriculum. While they do not directly correlate to our learning objectives, they do correlate with specific courses and topics taught within those courses.

There are many other important measures we are actively monitoring. These include student attitudes towards science, retention and progression rates in STEM and the influence of Chemistry courses on those items, the influence of learning environment on student learning, and student success (DFW vs. ABC grades). A review of some of these items is included in the results. These are items which are important to our personal professional development, to our external accreditation, to our obligations to external granting agencies (National Science Foundation), and/or the stated critical institutional goals of increasing student recruitment and retention. Assessment results and findings under current assessment plan.
Measurement of student learning – General Chemistry.

Prior to the last two years, we only assessed student learning at the end of the second semester (general chemistry II). We have recently changed our assessment tools (standardized exam) for general chemistry, utilizing standardized exams for each semester, and have not yet correlated the results with the learning objectives of the ACCM. Our prior assessment results from 2012 – 2015 broken down by topics (topic breakdown by ACS Exam Institute) are shown in Figure 2. There were no significant changes seen in 2016 or 2017 compared to prior years.

Measurement of student learning – Organic Chemistry. During this assessment period, we updated our standardized exam from an extremely old version to a newer version. We have not yet begun tabulating results from the new exam, nor tying these results to the ACCM. It is anticipated that this should be easier for this new exam, as newer exams are being developed with the ACCM content standards in mind.

Results from the older exam are shown in Figure 6. It was noted that UWRF students lag behind national norms in nearly all identified content areas, but most notably chemical synthesis, acid/base chemistry, and stereochemistry.
Measurement of student learning – Biochemistry Threshold.

Figure 7. Biochemistry threshold exam results. The height of the bar (Y axis) represents the percentage of students who are determined to be ready for biochemistry. The blue bar represents chemistry majors, the red bar represents all students.

The Biochemistry Threshold exam is a recent addition to our assessment protocol. It is an attempt to determine whether students are ready for biochemistry. Results are shown in Figure 7.

The results of the exam show that our students are, for the most part, not prepared for success in Biochemistry (CHEM 361/362 or 360). The department is currently evaluating the results and is beginning discussions to identify why the students are not prepared, and what changes can be made in our lower-level curriculum to address the issue.
Measurement of student learning – Diagnostic of Undergraduate Content Knowledge.

The ACS Exam Institute publishes a Diagnostic of Undergraduate Content Knowledge (DUCK) exam which the department has been administering to graduating seniors for the past several years. Department faculty have identified questions in the exam which are most pertinent to courses in

**Table 3. DUCK exam item analysis for UWRF graduating Chemistry majors.**

<table>
<thead>
<tr>
<th></th>
<th>National Mean Item Sum</th>
<th>Intro Course Sequence</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score Correct, 60 items</td>
<td>31.49</td>
<td>All Students</td>
<td>129</td>
<td>31.74</td>
<td>7.44</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>31.40</td>
<td>7.40</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>33.25</td>
<td>7.60</td>
<td>1.55</td>
</tr>
<tr>
<td>General Chemistry I &amp; II (C121, C122), 9 items</td>
<td>4.94</td>
<td>All Students</td>
<td>129</td>
<td>4.74</td>
<td>1.72</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>4.66</td>
<td>1.72</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>5.08</td>
<td>1.69</td>
<td>0.34</td>
</tr>
<tr>
<td>Organic chemistry I &amp; II (C231, 236, 232, 237), 23 items</td>
<td>13.75</td>
<td>All Students</td>
<td>129</td>
<td>14.19*</td>
<td>3.39</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>13.89*</td>
<td>3.40</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>15.50*</td>
<td>3.09</td>
<td>0.63</td>
</tr>
<tr>
<td>Analytical and Instrumental (C250, C356), 10 items</td>
<td>4.74</td>
<td>All Students</td>
<td>129</td>
<td>4.47</td>
<td>1.69</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>4.55</td>
<td>1.73</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>4.08*</td>
<td>1.47</td>
<td>0.30</td>
</tr>
<tr>
<td>Thermo (C341), 6 items</td>
<td>2.92</td>
<td>All Students</td>
<td>129</td>
<td>2.67*</td>
<td>1.19</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>2.62*</td>
<td>1.19</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>2.88</td>
<td>1.19</td>
<td>0.24</td>
</tr>
<tr>
<td>Quantum (C342), 5 items</td>
<td>2.82</td>
<td>All Students</td>
<td>129</td>
<td>2.50*</td>
<td>1.37</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>2.50*</td>
<td>1.43</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>2.50</td>
<td>1.06</td>
<td>0.21</td>
</tr>
<tr>
<td>Inorg (C422/322), 7 items</td>
<td>3.39</td>
<td>All Students</td>
<td>129</td>
<td>3.19</td>
<td>1.56</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>105</td>
<td>3.19</td>
<td>1.60</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic 1st</td>
<td>24</td>
<td>3.21</td>
<td>1.38</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Figure 8. UWRF student performance on the ACS DUCK exam, by quartile.
the major, including general chemistry, analytical chemistry, organic chemistry, biochemistry, inorganic chemistry, and physical chemistry (thermodynamics – CHEM 341 and quantum mechanics and spectroscopy, CHEM 342). The overall results are graphed in Figure 8. Table 3 shows the results broken down by discipline, with areas where UWRF students are performing statistically significantly above or below the national average highlighted (above average in italics, below in red bold).

It is seen that our graduates lag behind national norms in topics in the two physical chemistry courses (CHEM 341 and CHEM 342) – essentially Content Knowledge Learning Objectives 1 (Atoms), 2 (Bonding), 6 (Energy and Thermodynamics), and 8 (Equilibrium). Only one of the two physical chemistry courses is required for graduation. The other is allowed as an elective; most students take only CHEM 341. To address this issue, the department recently changed the curriculum to require both CHEM 341 and CHEM 342 of all graduates.

**Measure of student learning - Structure-Function survey.**

*Figure 6 Results of structure-function test, pretest (Gen Chem I), post test (Gen Chem II, Organic II, Biochemistry).*

We have recently begun a survey of student knowledge relative to the relationship between chemistry structure and function (Content Knowledge Learning Objective 3). The results show that, not surprisingly, our students come in with little or no knowledge of aspects of the relationship between structure and function, and gain more understanding as they progress. Problem areas appear to include chemical reactivity and acid/base chemistry.

**Measurement of student learning – Laboratory safety.**
The CHEM 261 course has been specifically designed to teach students to recognize chemical hazards, to assess the risk of these hazards, to minimize the risks of the hazards, and to prepare for emergency situations. The course assessments (including daily assignments, exams, and a long term project) are intended with Professional Skills Learning Objective 1 in mind. For this
reason, we are using the course final grades as a measure of how well students have achieved this learning outcome.

The average grade is shown in Figure 7, and has been about 2.9 on a four point scale. This correlates with percentile score of around 78%. The course has been taught using a flipped classroom approach. Based upon the assessment results this approach seems to be working. On an anecdotal level, several graduates have indicated that they have found jobs and advancement because of their lab safety knowledge.

**Trends in assessment results and impact on curriculum**

While we have aggregated data which we have used to inform curricular change, we have not gathered enough data to identify clear and/or significant trends on curriculum. We feel that we get too much scatter in the year-to-year data at this point to identify clear trends.

**III. Assessment of results and findings under previous assessment plan.**

These are presented in our prior report and are not included here.

**b) Results from out-of-classroom experiences.**

As stated in section II.f), our curriculum does not mandate what this rubric considers “out-of-classroom” experiences. We do collect (and submit to the ACS for accreditation) on an annual and periodic (5-7 year) basis various indirect measures of student achievement and learning which address out-of-classroom learning objectives. These include degree level, certification status of graduates, and supplemental information on the curriculum and faculty (annual) and facilities and equipment status, course syllabi, course exams, and student research reports (periodic).
c) **Indirect student assessment results and meaning.**

The department is engaged in a variety of important indirect student assessments, many of which are supported by current funding from the National Science Foundation. One of our primary objectives is to identify those factors which are important for student progression and retention – related to our institutional goal of academic excellence.

**Student Demographics.**

One of our major assessment efforts is to try to understand the factors behind student success in STEM. Table 2 shows the demographics of our students who declared a chemistry major at the beginning of their first term in Fall 2012 through Fall 2015. We have only included enrollees up to Fall 2015 because we wish to track student progression into their third year (and students enrolled since that point have not had time to reach their third year).

A survival analysis of STEM students entering the university since 2012 has shown that the primary factor determining retention is the grade in the first STEM course. Students who receive a poor grade in their first STEM course are unlikely to continue either in their course of study or at UWRF. Table 3 shows the average first grades of Chemistry majors since Fall 2012 in STEM courses including introductory Math and Biology. The data shows that the most likely barrier to student progression is CHEM 130, the first course in our Organic First sequence. This topic has been brought up for discussion in the department, with no decision made as to how to alleviate.

| Table 2. New to college students who declared chemistry at the beginning of their first term (Fall 12, Fall 13, Fall 14, or Fall 15), N=71 |
|-----------------|----------------|---------|-----------|
|                 | N   | Mean | StdDev | Median   |
| HS GPA          | 68  | 3.35 | 0.50   | 3.43     |
| HS Percentile   | 53  | 68.47| 23.26  | 74.00    |
| Math Placement  | 59  | 89.32| 22.35  | 90       |
| ACT Composite   | 70  | 23.93| 3.58   | 23.50    |
| ACT Math        | 70  | 24.99| 4.01   | 24.00    |

| Table 3. Average first grades in STEM courses for students who declared a chemistry major in their first term, Fall 2012 – Fall 2015, fall new students only. |
|-----------------|----------------|---------|-----------|
|                 | N   | Mean | StdDev | Median |
| Math 149        | 30  | 2.79 | 1.14   | 2.83    |
| Math 166        | 43  | 2.56 | 1.20   | 2.67    |
| Phys 131        | 27  | 3.00 | 0.77   | 3.00    |
| Biol 150        | 41  | 3.14 | 0.81   | 3.00    |
| Chem 121        | 37  | 2.50 | 1.16   | 3.00    |
| Chem 130        | 24  | 2.22 | 1.07   | 2.33    |
Figure 8. Fate of declared chemistry majors by their third year after initial enrollment.

Student Progression.
Figure 8 shows the fate of students who enrolled as Chemistry majors since 2012. Only 40% of those students were still enrolled in Chemistry in their fifth term (third year). Of those students who left UWRF, 38.5% enrolled in a 2 year school or tech, 34.6% enrolled in a 4 year school, mostly public PUI, and 26.9% never enrolled in a school as of 1/2018. While discussions with colleagues at other institutions tell us that our results are not unusual, we feel that we need to do better in student retention.

Course study hours and work hours.
One of our study questions was the extent that students studied for their Chemistry (and other) courses. All students in General Chemistry I and II, Organic Chemistry I and II, and Biochemistry were surveyed about the number of hours they studied for their chemistry course and the number of hours the studied overall. The results are shown in Figures 9 and 10. In addition, we asked students about the number of hours they worked during the academic year. Those results are shown in Figure 11.

The majority of students are spending from 3-5 hours per week studying for their Chemistry course. We feel this is insufficient for student learning. We also find that the majority of our students are working outside of the university less than 15 hours per week, undercutting the argument that our students need to spend too much time working to be academically successful.

We have not yet determined how these results might be useful towards improving student performance.
Figure 9. Average number of hours per week spent studying on their chemistry course, by students taking chemistry courses during the academic year, self-reported.

Figure 10. Average number of hours per week spent studying on all courses, by students taking chemistry courses during the academic year, self-reported.
Student attitudes towards Chemistry.
Student success in a field of study is closely tied to the student’s attitude toward the field. During this assessment period, we have been giving the test shown in Figure 12 as a pretest (general chemistry I) and posttest for several courses in the curriculum. The results of the test are scored for Intellectual Accessibility of the material, and for Emotional Satisfaction with the material.

Results are shown below in Table 4. It is noteworthy that students’ attitudes towards Chemistry decrease as they proceed through the curriculum – this has been noted in the literature. Our Organic First curriculum is somewhat different in the pattern of decrease in the introductory courses.

The results have not resulted in any departmental actions.
Table 4. Mean change in student attitudes towards chemistry, measured from course to course. Course numbers are the course typically taken. For example, 2 to 1post would be the change in attitude from the end of CHEM 111 to the end of CHEM 112 (gen chem I to gen chem II) for our traditional sequence, while it would correspond to the change from the end of CHEM 130 to the end of CHEM 233 in our Organic First sequence. Items which are starred are statistically significant.

<table>
<thead>
<tr>
<th>Course</th>
<th>Traditional</th>
<th></th>
<th></th>
<th>Organic First</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>IA</td>
<td>ES</td>
<td>N</td>
<td>IA</td>
<td>ES</td>
</tr>
<tr>
<td>1Post to 1Pre</td>
<td>1141</td>
<td>-0.104*</td>
<td>-0.244*</td>
<td>153</td>
<td>-0.250*</td>
<td>-0.204*</td>
</tr>
<tr>
<td>2 to 1Post</td>
<td>493</td>
<td>-0.431*</td>
<td>-0.411*</td>
<td>127</td>
<td>-0.220*</td>
<td>-0.187*</td>
</tr>
<tr>
<td>3 to 2</td>
<td>295</td>
<td>-0.491*</td>
<td>-0.32*</td>
<td>98</td>
<td>0.117*</td>
<td>-0.439*</td>
</tr>
<tr>
<td>4 to 3</td>
<td>291</td>
<td>-0.078</td>
<td>-0.156*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 to 4 or 5 to 3</td>
<td>271</td>
<td>0.295*</td>
<td>0.289*</td>
<td>54</td>
<td>-0.0648</td>
<td>0.00926</td>
</tr>
<tr>
<td>4 to 1 or 3 to 1</td>
<td>132</td>
<td>-0.581*</td>
<td>-0.342*</td>
<td>75</td>
<td>-0.383*</td>
<td>-0.793*</td>
</tr>
<tr>
<td>5 to 1</td>
<td>101</td>
<td>-0.193</td>
<td>0.057</td>
<td>43</td>
<td>-0.372*</td>
<td>-0.651*</td>
</tr>
</tbody>
</table>
**Student Performance – Peer-Led Team Learning.**

In Peer-Led Team Learning (PLTL), students engage in peer lead recitations. The peers are students who have been successful in the course and are trained in both content and pedagogy. We have found that students who participate in PLTL average up to a letter grade better performance in most courses. Data is shown in Table 5 below.

**Table 5. Student performance in PLTL vs non-PLTL students.**

<table>
<thead>
<tr>
<th></th>
<th>Chem 120 (6 credits)</th>
<th>Chem 121 (5 credits)</th>
<th>Chem 122 (5 credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PLTL</td>
<td>Non-PLTL</td>
<td>PLTL</td>
</tr>
<tr>
<td>Number of Students</td>
<td>30</td>
<td>92</td>
<td>39</td>
</tr>
<tr>
<td>Gender Count (M/F)</td>
<td>5/25</td>
<td>41/51</td>
<td>7/32</td>
</tr>
<tr>
<td>ACT Composite</td>
<td>21.89 (3.01)</td>
<td>21.87 (2.96)</td>
<td>24.81 (2.96)*</td>
</tr>
<tr>
<td>ACT Math</td>
<td>20.44 (3.26)</td>
<td>21.23 (3.38)</td>
<td>24.44 (2.96)</td>
</tr>
<tr>
<td>HS Percentile</td>
<td>68.52 (22.32)</td>
<td>57.59 (21.88)</td>
<td>79.67 (15.61)*</td>
</tr>
<tr>
<td>Term GPA</td>
<td>3.11 (0.82)*</td>
<td>2.29 (0.97)*</td>
<td>3.17 (0.72)*</td>
</tr>
<tr>
<td>Cumulative GPA</td>
<td>3.04 (0.81)*</td>
<td>2.45 (0.82)*</td>
<td>3.22 (0.66)*</td>
</tr>
<tr>
<td>Course Grade on 4 pt</td>
<td>3.10 (0.92)*</td>
<td>2.07 (1.20)*</td>
<td>2.75 (1.05)*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chem 130 (5 credits)</td>
<td>Chem 231 (3 credits)</td>
<td>Math 149 (3 credits)</td>
</tr>
<tr>
<td></td>
<td>Mean (Stdev)</td>
<td>Mean (Stdev)</td>
<td>Mean (Stdev)</td>
</tr>
<tr>
<td></td>
<td>PLTL</td>
<td>Non-PLTL</td>
<td>PLTL</td>
</tr>
<tr>
<td>Number of Students</td>
<td>20</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>Gender Count (M/F)</td>
<td>4/16</td>
<td>18/21</td>
<td></td>
</tr>
<tr>
<td>ACT Composite</td>
<td>25.40 (3.62)</td>
<td>24.97 (3.30)</td>
<td>24.00 (3.33)</td>
</tr>
<tr>
<td>ACT Math</td>
<td>25.20 (4.34)</td>
<td>25.00 (3.26)</td>
<td>25.58 (4.52)</td>
</tr>
<tr>
<td>HS Percentile</td>
<td>78.19 (21.41)</td>
<td>72.77 (20.59)</td>
<td>84.37 (10.92)</td>
</tr>
<tr>
<td>Term GPA</td>
<td>3.22 (0.72)*</td>
<td>2.39 (1.11)*</td>
<td>3.53 (0.48)*</td>
</tr>
<tr>
<td>Cumulative GPA</td>
<td>3.22 (0.72)*</td>
<td>2.42 (1.10)*</td>
<td>3.62 (0.39)*</td>
</tr>
<tr>
<td>Course Grade on 4 pt</td>
<td>2.75 (0.84)*</td>
<td>1.82 (1.14)*</td>
<td>3.05 (0.87)*</td>
</tr>
</tbody>
</table>

*Indicates significant (p<0.05) differences between PLTL and non-PLTL student outcome
The population in PLTL is overwhelmingly female, and a general trend of PLTL students out performing non-PLTL students in the course, term GPA, and cumulative GPA. In most courses, the non-PLTL student ACT and HS Percentile scores were similar to the non-PLTL student ACT and HS Percentile scores.

Table 6 shows a summary of all females in all courses offering PLTL with PLTL participants and non-PLTL participants separated. NOTE: Gender data for Fall 2015 Chem 231 and 122 is currently missing.

As a result of this work, the department is currently piloting a substitution of discussion sections of Gen Chem I with PLTL sections, making the program mandatory.

**Graduating student survey.**

Results of our survey of graduating students are shown below in Table 7. Results appear to correlate with expectations.

<table>
<thead>
<tr>
<th>Outcome Number</th>
<th>Outcome Description (i.e. question asked)</th>
<th>Painful</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Disagree</th>
<th>Missing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I can describe matter in terms of atoms, molecules and ions.</td>
<td></td>
<td>17</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>I had hands-on experience with modern chemical instrumentation (e.g. IR, NMR, UV-Vis, GC, GCMS, HPLC, etc.)</td>
<td></td>
<td>18</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>I am able to retrieve chemical information using tools such as SciFinder, Reaxys, Google Scholar, PubMed</td>
<td></td>
<td>14</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>My problem-solving and critical thinking skills have improved as a result of the UWRF Chemistry Program</td>
<td></td>
<td>16</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>I have developed a foundational understanding of laboratory safety (e.g. dress rules, when/how to use fume hoods, purpose/use of safety/emergency equipment (eyewash, safety shower, for extinguisher), etc.)</td>
<td></td>
<td>18</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
</tbody>
</table>

**Table 7. Cumulative results for Departmental graduation student survey, 2014 through 2015.** No statistically significant trends were seen between the two years.
d) **Indirect alumni assessment results.**

We maintain contact with many of our alumni as they go into industry, government, professional or graduate schools. Points of contact include return visits, our annual Family Day, our department Facebook page, and personal notes (email and regular mail). There are two consistent points which emerge from these discussions:

- **The value of our student laboratory experience.** Alumni state that, compared with many of their colleagues from other institutions, they have a higher level of direct experience with instrumentation and with open-ended problem solving. Several alumni have stated that they received job offers as a direct result of specific laboratory experiences during their degree.

- **The value of our student seminar.** Although the students view the Chemistry seminar (CHEM 480) as stressful, when they come back as alumni they state that their experience researching and presenting a topic sets them apart from their colleagues from other institutions.

e) **Indirect professional assessment results and meaning.**

Our last ACS programmatic review has been discussed at length in other sections. The key professional assessment results stated that our students needed to improve their undergraduate research and chemical literature skills. To improve these outcomes, the Department implemented CHEM 380: Junior Seminar.
IV. Action Plans.

a) Action plan – Where/how performance is or is not meeting expectations.
Results on the DUCK exam showed that graduates were deficient in content knowledge associated with the two Physical Chemistry courses – CHEM 341 and CHEM 342. We have addressed this problem by requiring both courses for graduation. We will continue to monitor student performance on these learning objectives.

Instructors for Biochemistry have felt that students coming into the class are not prepared for the material. The Structure-Function test and the Biochemistry Threshold test appear to validate this concern.

Biochemistry faculty have responded by including a week of “remediation” at the start of the course. We are starting a departmental conversation about how we can improve student readiness through changes in lower-level courses.

We will continue monitoring, conversation, and intervention (changes in curriculum) as necessary.

b) Action plan – Maintain/improve individual learning outcomes.
Our individual learning outcomes are recommended by our external approving body. We will continue to integrate the concept map into our course assessment, will continue to monitor how the ACS implements these learning outcomes, and how it assesses them through available standardized exams.

c) Action plan – Maintain/improve out-of-classroom learning experiences.
The ACS-CPT has recommended that we do a better job of assessing student papers in our research course. We are implementing these changes, through allowing for (and encouraging) more research credits for each student. We will attempt to continue PLTL, including finding funding for a coordinator. Literature shows that this not only improves the performance of the students taking the course, but also improves outcomes for the peer leaders.

V. Recommendation for Improving Assessment Process

a) Action plan – Maintain/improve indirect student assessment.
The Department is committed to maintaining and improving its current indirect student assessments, for our own continuous improvement, to meet the institutional goals of increased student retention and graduation, and as mandated by our external stakeholders. Having said that, we will be making an effort to streamline our assessment effort in the next time period.
Our experience with open-ended questions in our Biotechnology student graduation survey has given us useful feedback. For Chemistry, we will continue with our current graduation survey, but will add these open-ended questions.

Several of the student surveys mentioned here in this report will not be continued.

We will need to establish an assessment protocol for our professional learning objectives. We had resolved to do this in our last cycle, but it was neglected.

b) **Action plan – Maintain/improve indirect alumni assessment.**

We will continue on our current course, maintaining connections with our alumni, and continuing informal conversations during our Family Day event.

c) **Action plan – Maintain/improve indirect professional assessment.**

We will continue to work with ACS and the ACS-CPT to meet their requirements for program approval.

d) **Action plan – Maintain/improve assessment process.**

We look to maintain our process, but as mentioned earlier, we are looking to streamline. Several of the surveys will be discontinued. We intend to review our assessment plan next year. We have also been encouraging faculty teaching the same courses to meet regularly and collaborate on content, pedagogy, and assessment.

We will need to establish an assessment protocol for our professional learning objectives. We had resolved to do this in our last cycle, but it was neglected.

The department should also review its assessment plan.
### e) Action plan – Action plan summary table.
#### Chemistry Action Plan summary.

There are no milestones listed for continuous actions.

<table>
<thead>
<tr>
<th>Item</th>
<th>Action</th>
<th>Milestone</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Load</td>
<td>Push to reach lecture-lab equivalency and reduce class sizes</td>
<td>Restore faculty positions lost in recent years</td>
<td>When pigs fly.</td>
</tr>
<tr>
<td>Where/how performance is or is not meeting expectations.</td>
<td>Improve student performance in Physical Chemistry content.</td>
<td>Students required to take both courses.</td>
<td>Was implemented beginning Fall 2018 entering class; should start to take effect in Fall 2020.</td>
</tr>
<tr>
<td></td>
<td>Improve readiness of students entering Biochemistry.</td>
<td>Improvement in Biochemistry Threshold exam scores.</td>
<td>Discussions among faculty through 2018-19 academic year to determine specific actions in lower-level courses (if any).</td>
</tr>
<tr>
<td>Maintain/improve individual learning outcomes.</td>
<td>Monitor ACS and ACS-CPT actions to expand and implement content map, make changes as appropriate.</td>
<td></td>
<td>Continuous</td>
</tr>
<tr>
<td>Maintain/improve out-of-classroom learning experiences.</td>
<td>Continue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintain/improve indirect student assessment.</td>
<td>Streamline assessment through evaluation of current surveys.</td>
<td></td>
<td>Continuous</td>
</tr>
<tr>
<td>Maintain/improve indirect alumni assessment.</td>
<td>Maintain current informal assessment.</td>
<td></td>
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<tr>
<td>Maintain/improve indirect professional assessment.</td>
<td>Continue to monitor ACS-CPT requirements and change curriculum as necessary to maintain approval.</td>
<td></td>
<td>Next review (2023)</td>
</tr>
<tr>
<td>Maintain/improve assessment process.</td>
<td>Hold regular departmental assessment meetings.</td>
<td>Meetings are held.</td>
<td>Annually</td>
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<td></td>
<td>Develop assessment protocols for professional learning objectives.</td>
<td>Protocols are developed, assessment plan revised, data collected.</td>
<td>Protocols developed by September 2019.</td>
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<tr>
<td></td>
<td>Review assessment plan.</td>
<td>Plan reviewed and revised as necessary.</td>
<td>September 2019</td>
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</tbody>
</table>
V. Data from Institutional Research
   a) Number of majors.
   b) Number of faculty.
VI. Attachments


Dr. Karl Peterson, Chair
Department of Chemistry
University of Wisconsin-River Falls
410 S. Third Street
River Falls, WI 54022

Dear Dr. Peterson:

Congratulations! The Committee on Professional Training (CPT) reviewed your department’s 2017 periodic report, determined that your department meets all of the requirements in the ACS Guidelines, and voted to continue approval for your program. Your department can continue to provide ACS Certificates to its graduates.

Program Strengths: The quality of your program and the new grant funds are praiseworthy. The extensive improvements to the infrastructure and curriculum demonstrates the level of administrative support given to the department. The dedicated course in polymer chemistry and the content in biochemistry are excellent ways to satisfy the MSN requirement.

The following suggestions were made during your review, which may facilitate the continued development of your chemistry program:

Teaching contact hours. According to your report, the teaching contact hours are very close to the maximum allowed in the ACS Guidelines. Please remember that faculty members may not exceed the maximum contact hours specified in the guidelines in order to allow time for curriculum and professional development activities.

Student skills: Your periodic review did not contain evidence that formal ethics training was included in the curriculum. Please incorporate this training into your existing courses. The Teaching Professional Ethics supplement offers guidance on how you can foster the development of this important skill.

Research: The research reports submitted were limited in scope and were structured like lab reports. Please review the goals of your undergraduate research program to offer students a more extended and substantial research experience. The undergraduate research supplement describes ways in which this can be accomplished.
While pleased to see that the university’s catalog highlights ACS recognition of the chemistry program, please note that the American Chemical Society process is “approval” rather than “accreditation.” Please make the appropriate correction in your catalog at your earliest convenience.

Your department’s next periodic report is due in 2023.

The staff in the Office of Professional Training is available to answer any questions you might have. Please feel free to contact us at cpt@acs.org or at 202-872-4589.

We wish you every success as you strive to provide the very best training for your students.

Sincerely,

[Signature]
Derrick T. Hendricks
Project Manager, Office of Professional Training

[Signature]
Michelle M. Brooks, Ph.D.
Senior Manager, Office of Professional Training
Associate Liaison, Committee on Professional Training

MMB/dth/daa
### b) Chemistry Program Assessment Artifacts and Venues

<table>
<thead>
<tr>
<th>Learning Objective Title</th>
<th>Description –</th>
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</thead>
<tbody>
<tr>
<td><strong>Content Learning Objectives</strong></td>
<td>Chemistry graduates from the University of Wisconsin – River Falls will be able to</td>
</tr>
<tr>
<td>1.A. Atoms</td>
<td>describe matter in terms of atoms that have internal structures that dictate their chemical and physical behavior</td>
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<tr>
<td>1.B. Bonding</td>
<td>explain chemical bonds in terms of atoms interacting via electrostatic forces</td>
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<tr>
<td>1.C. Structure and Function</td>
<td>connect chemical and physical behaviors with chemical compound geometric structure</td>
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<tr>
<td>1.D. Intermolecular Forces</td>
<td>compare and contrast intermolecular forces – electrostatic forces between molecules – and apply these forces to explain chemical and physical properties</td>
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<tr>
<th>Classroom venues</th>
<th>Out of Classroom Venues</th>
<th>Other</th>
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<tbody>
<tr>
<td>General Chemistry - Chem 111, 112, 130, 240</td>
<td>Internships</td>
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<tr>
<td>Organic Chemistry - Chem 251, 252, 253</td>
<td>Research</td>
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<tr>
<td>Analytical Chemistry - Chem 250</td>
<td>Off-campus research</td>
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<tr>
<td>Laboratory Safety - Chem 260</td>
<td>Seminar</td>
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<tr>
<td>Physical Chemistry - Chem 340/341/342</td>
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<td>Advanced Analytical Laboratories - Chem 354/58</td>
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<tr>
<td>Biochemistry - Chem 360/361/362/366</td>
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<tr>
<td>Internships</td>
<td>Research</td>
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<td></td>
<td>Off-campus research</td>
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<td>Seminar</td>
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- ACS exam
- ACS exam (342)
- ACS DUCK Exam
- ACS DUCK Exam
- ACS DUCK Exam

- [1]

**Stakeholders**

- internal (programs we service)
- American Chemical Society (Accreditation)
- other

- Student feedback
- Alumni feedback
- Stakeholders - internal (programs we service)
- Stakeholders - American Chemical Society
- Stakeholders - other
<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Exams</th>
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<tbody>
<tr>
<td><strong>1.E. Reactions</strong></td>
<td>predict and analyze how matter changes, forming products that have new chemical and physical properties</td>
<td>ACS exam</td>
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<tr>
<td><strong>1.F. Energy and Thermodynamics</strong></td>
<td>articulate that energy is the key currency of chemical reactions in molecular-scale systems as well as macroscopic systems</td>
<td>ACS exam (342)</td>
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<tr>
<td><strong>1.G. Kinetics</strong></td>
<td>interpret and describe chemical changes as it relates to time scale over which they occur</td>
<td>ACS DUCK Exam</td>
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<tr>
<td><strong>1.H. Equilibrium</strong></td>
<td>describe how all chemical changes are, in principle, reversible and that chemical processes often reach a state of dynamic equilibrium</td>
<td>ACS DUCK Exam</td>
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<tr>
<td><strong>1.I. Experiments, Measurement, and Data</strong></td>
<td>design, implement, and interpret experiments to validate experimental hypotheses</td>
<td>ACS DUCK Exam</td>
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<tr>
<td><strong>1.J. Visualization</strong></td>
<td>construct meaning by visualizing chemistry at the symbolic, particulate, and macroscopic levels</td>
<td>ACS DUCK Exam (342)</td>
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# Professional Skills Learning Objectives

Chemistry graduates from the University of Wisconsin – River Falls will be able to

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<tr>
<td>2.A. Problem-Solving</td>
<td>define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, and draw appropriate conclusions.</td>
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<td>2.B. Chemical Literature</td>
<td>use the peer-reviewed scientific literature effectively and evaluate technical articles critically.</td>
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<td>2.C. Laboratory Safety</td>
<td>understand responsible disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets (MSDS), recognize and minimize potential chemical and physical hazards in the laboratory, and know how to handle laboratory emergencies effectively.</td>
<td>Safety laboratory</td>
<td>Course grade</td>
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<td>2.D. Communication</td>
<td>present information in a clear and organized manner, write well-organized and concise reports in a scientifically appropriate style, and use technology such as poster preparation software, word-processing, chemical structure drawing programs, and computerized presentations in their communication.</td>
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<td></td>
<td>Written lab reports</td>
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<td>2.E. Team Skills</td>
<td>work effectively in a group to solve scientific problems, be effective leaders as well as effective team members, and interact productively with a diverse group of peers.</td>
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<td>2.F. Ethics</td>
<td>conduct themselves responsibly and be aware of the role of chemistry in contemporary societal and global issues.</td>
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