Chemistry Major Assessment Plan

MISSION STATEMENT: The UWRF Chemistry 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.

Background The discipline of Chemistry connects physics, biology, materials science, engineering and medicine. Chemists are at the forefront of diverse industries including pharmaceuticals, biotechnology, pharmaceuticals, petroleum, personal care products, environmental technologies, and materials engineering.

Chemistry is traditionally divided into five foundational areas: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry. This foundation allows students to pursue in-depth studies and experiences that tailor the educational to the student’s strengths and interests, as well as the needs of the chemical industry. Much of the current excitement in chemistry involves interdisciplinary and cross sub-disciplinary applications.

Chemistry differs from many fields of study in that core skills normally taught outside of course structure are taught in our laboratories and/or seminar. These core skills include critical thinking, problem solving, oral and visual communication, information retrieval and management, group work, ethics, and safety.

Chemistry Program Goals:

A. 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).

B. UWRF Chemistry degree recipients shall meet or exceed the standards in Student Professional Skills expected by the American Chemical Society Committee on Professional Training (ACS-CPT).

C. The UWRF Chemistry Department shall maintain program faculty, staff, and budget which meet national standards as outlined by the ACS-CPT.

D. The UWRF Chemistry Department shall maintain infrastructure which meets national standards as outlined by the ACS-CPT.

E. The UWRF Chemistry Department shall work to implement institutional goals, including the University’s Mission, Vision, Strategic Plan, and General Education.

Program goals A & B deal directly with student learning outcomes and are evaluated as part of this Assessment Plan. Goals C and D are indirect measures of programmatic quality and are requirements for our accreditation by the American Chemical Society. Goal E reflects the Department’s responsibility to the College of Arts and Sciences and to the broader University community.
I. Learning Outcomes

a. Learning outcomes for the Chemistry Program.

The learning outcomes for the Chemistry Department are divided into Content Knowledge Learning Outcomes and Professional Skills Learning Outcomes.

In Chemistry Student Content Knowledge, UWRF Chemistry graduates will be able to:

A.1 describe matter in terms of atoms that have internal structures that dictate their chemical and physical behavior (Big Idea I – Atoms).
A.2 explain chemical bonds in terms of atoms interacting via electrostatic forces (II – Bonding).
A.3 connect chemical and physical behaviors with chemical compound geometric structure (III – Structure and Function).
A.4 compare and contrast intermolecular forces – electrostatic forces between molecules – and apply these forces to explain chemical and physical properties (IV – Intermolecular Forces).
A.5 predict and analyze how matter changes, forming products that have new chemical and physical properties (V – Reactions).
A.6 articulate that energy is the key currency of chemical reactions in molecular-scale systems as well as macroscopic systems (VI – Energy and Thermodynamics).
A.7 interpret and describe chemical changes as it relates to time scale over which they occur (VII – Kinetics).
A.8 describe how all chemical changes are, in principle, reversible and that chemical processes often reach a state of dynamic equilibrium (VIII – Equilibrium).
A.9 advance knowledge through experimental observation (IX – Experiments, Measurement, and Data).
A.10 construct meaning by visualizing chemistry at the symbolic, particulate, and macroscopic levels (X – Visualization).

Our Professional Skills Learning Outcomes are based upon the requirements of the ACS-CPT. Appendix A gives a complete list of the CPT’s expectations. It is our intent that we will (over the next several years) include learning outcomes for many or all of these expectations in our university assessment plan. For now, we will be using the subset of learning outcomes below:

In Chemistry Student Professional Skills, UWRF graduates will be able to

B.1 design and execute the synthesis of molecules and utilize modern instrumentation to measure chemical structure, properties, and phenomena. (Laboratory skills)
B.4 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)
B.5 present information in a clear, organized, and technically appropriate manner. (Communication Skills)
b. Measurement of Learning Outcomes

Student Content Knowledge outcomes are measured through specific items on nationally standardized exams as described in the Assessment Venue section. Student Professional Skills outcomes are measured through three venues – the first through questions on national standardized exams (same as content knowledge outcomes), the second through performance in Chemistry 261, Laboratory Safety, and the third through the student’s senior seminar (Chemistry 480).

c. Learning Outcomes and External Stakeholders

The learning outcomes adopted by the UWRF Chemistry Department are adapted from ACS-CPT expectations for our program, as expressed through the ACS Anchoring Concept Content Map (ACCM)¹ and the ACS-CPT document ACS Guidelines for Bachelor’s Degree Programs (aka the Guidelines) and its associated supplements ².

The ACS-CPT is charged with promoting excellence in postsecondary education and providing leadership in the professional training of chemists. The Guidelines and accompanying program certification represent the de facto standard for the professional expectations of chemists. Our external stakeholders, including prospective employers, graduate schools in Chemistry and Biochemistry, and professional schools including medical, veterinary, and pharmacy schools, all expect that our graduates meet this standard.

Content Knowledge Learning Outcomes.

The ACS-CPT requires that students must take foundational courses (at least three credits) in all of the five foundational areas of chemistry and at least twelve credits of in-depth coursework. Every student’s program may be different as students have options in the in-depth courses they take. Because of this, we are using the broader topics of the ACS Anchoring Concept Content Map (ACCM) rather than course-specific assessments as the basis for our Content Knowledge Learning Outcomes.

The ACCM contains 10 “Big Ideas”, with further articulation (from reference 1):

“They (the big ideas) connect to slightly finer-grained ideas called enduring understandings, which define the most important features of the big ideas (level 2). Enduring understandings are then articulated for subdisciplines in chemistry (level 3 in “pill boxes”), and finally the content details of courses in chemistry compose the final, fine-grained level (level 4) of the ACCM content.”

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We have adopted these ten “Big Ideas” into Content Knowledge Learning Outcomes. The ACS-CPT is engaged in an ongoing effort to map these concepts onto the subdisciplines of chemistry and the content details of courses.

These learning outcomes will be measured through specific items on nationally standardized exams as described in the Assessment Venue section.

**Professional Skills Learning Outcomes**

The ACS-CPT 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.”

Appendix A gives a complete list of the CPT’s expectations for Professional Skills. It is our intent that we will gradually expand our learning outcomes to encompass most or all of these expectations.

**d. Outcomes and their link to UWRF strategic goals and initiatives.**

The University’s three strategic goals are 1) Distinctive Academic Excellence, 2) Global Education and Engagement, and 3) Innovation and Partnerships.

We promote academic excellence in our program by aligning our programmatic learning outcomes to national standards. Our learning outcomes are innovative in that we are among the first to be utilizing the ACS Anchoring Concept Content Map in our program assessment. Another innovation is our Laboratory Safety course, which has received national attention.

The Department’s learning outcomes are most closely linked to

- Initiative 2012-6: Undergraduate Research, Scholarship, and Creative Activity. Students are encouraged to do RSCA during their time at UWRF (either on-campus or at another institution).
- Initiative 2012-10: Active Learning Classrooms. Several members of the Department are engaged in an effort to modify courses to utilize the new Hagestad ALC and to assess the resulting changes in student learning.
Finally, the Chemistry Department’s Program Goals (page 1) explicitly include

E. The UWRF Chemistry Department shall work to implement institutional goals, including
   the University’s Mission, Vision, Strategic Planning, and General Education.

Much of the Department’s effort to meet this goal are not directly reflected in our student
learning outcomes.
II. Learning Profile

a. Specific courses identified for each learning outcome.

Our curriculum is divided into Introductory, Foundational, In-depth, and Capstone experiences. Laboratory, where students get hands-on experience, is required in the first three divisions and is encouraged in the Capstone. Student content knowledge is introduced in the Introductory and Foundational courses and then expanded in the In-depth courses. Student professional skills are developed through the Foundational, In-depth, and Capstone experiences, especially through the laboratories.

The Chemistry major is a broad-field major because of Chemistry’s position as a central science. Students in Chemistry are required to take Cognate courses in Physics, Mathematics, and Biology.

The Chemistry curriculum typically consists of
- An introductory chemistry course (General Chemistry), an introduction to concepts required for foundational coursework;
- Courses in the foundational areas of Analytical, Organic, Inorganic, Physical, and Biochemistry;
- In-depth courses or electives, typically tied to the foundational areas (i.e. Physical Chemistry II, Advanced Inorganic Chemistry, etc.);
- Cognate courses in Biology, Physics, and Mathematics;
- An opportunity for a capstone experience of some sort, usually undergraduate research.

The ACS Curricular Concept Map, rather than focusing on the foundational subdisciplines, is intentionally drawn across courses and disciplines. Therefore our learning outcomes are learned in all courses – introduced in the introductory and foundational courses, and then reinforced and enhanced in the in-depth courses and capstone experiences.

e. Course map indicating different levels of learning and skill development.

The coursework of the Chemistry program is organized to meet the expectations of the ACS-CPT for the granting of certified degrees. Those expectations include introductory coursework, foundational coursework that provides breadth of chemistry knowledge, and in-depth coursework that builds on the foundation. The departmental Content Learning Outcomes are developed during these courses.

Because chemistry is an experimental science, the CPT also requires that substantial laboratory work be a part of the student’s education. The departmental Professional Skills Learning Outcomes are developed through this laboratory experience and the departmental capstone experiences (student research and seminar).
Our curricular map is shown on the next page. The courses are designed to meet the requirements of the ACS-CPT Guidelines.

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## Chemistry Department Course Map

### Introductory – Introduction of student learning outcomes

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 120* or 121*, 122*</td>
<td>General Chemistry I &amp; II</td>
</tr>
<tr>
<td>Chem 130*, 240*</td>
<td>Introductory courses in our Organic First curriculum</td>
</tr>
</tbody>
</table>

### Foundational Courses – Reinforcement of student learning outcomes

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 231, 232, 236†, 237† or 233*</td>
<td>Organic Chemistry</td>
</tr>
<tr>
<td>Chem 250*</td>
<td>Analytical Chemistry</td>
</tr>
<tr>
<td>Chem 340 or Chem 341 or Chem 342</td>
<td>Physical Chemistry</td>
</tr>
<tr>
<td>Chem 322*</td>
<td>Inorganic Chemistry</td>
</tr>
<tr>
<td>Chem 360 or Chem 361</td>
<td>Biochemistry</td>
</tr>
</tbody>
</table>

### In-depth courses – Enhancement of student learning outcomes

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 333, 334†</td>
<td>Organic Synthesis</td>
</tr>
<tr>
<td>Chem 355†, 356†</td>
<td>Analytical Chemistry</td>
</tr>
<tr>
<td>Chem 341 or 342, 402†</td>
<td>Physical Chemistry</td>
</tr>
<tr>
<td>Chem 401†, 422</td>
<td>Inorganic Chemistry</td>
</tr>
<tr>
<td>Chem 362, 366†</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>Chem 261</td>
<td>Laboratory Safety</td>
</tr>
<tr>
<td>Chem 311</td>
<td>Polymer Chemistry</td>
</tr>
<tr>
<td>Chem 461</td>
<td>Pharmacology</td>
</tr>
</tbody>
</table>

### Capstone and other out-of-class experiences

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 480</td>
<td>Chemical Communications (Seminar)</td>
</tr>
<tr>
<td>Chem 495</td>
<td>Internships</td>
</tr>
<tr>
<td></td>
<td>Chem Demons (Chemical demonstration student group)</td>
</tr>
</tbody>
</table>

### Cognate courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phys 161/162 or 151/152</td>
<td>Introductory Physics. Other Physics courses that can be taken for Chemistry credit include Phys 465 (Quantum Mechanics)</td>
</tr>
<tr>
<td>Biol 150 or 160</td>
<td>Introductory Biology. Other Biology courses that can be taken for Chemistry major credit include Biol 451 (Molecular Biology).</td>
</tr>
<tr>
<td>Math 166</td>
<td>Calculus I. Depending upon the major emphasis, up to two additional Math courses may be required, which might include Math 167 (Calc II), 266 (Calc III), 236 (Discrete Math), 256 (Linear Algebra), 326 (Applied Statistics), 346 (Numerical Analysis), or Phys 361 (Mathematics of Physics and Engineering)</td>
</tr>
</tbody>
</table>

Courses with laboratory are designated with an asterisk (*); those that are lab-only are designated with †.

### Introductory courses – Introduction to Student Content and Skills Objectives

The introductory or general chemistry experience plays an important role for all students. It provides a common background for students with a wide range of high school experiences.
We have two introductory sequences, the traditional (General Chemistry I and II, Chemistry 120/121 and 122) sequence and the Organic First sequence (which starts with Introduction to Organic Chemistry, Chemistry 130).

These introductory courses serve dual roles, for Chemistry majors and for other students. The vast majority of students in these courses are not Chemistry majors. For this audience, the courses provide their sole exposure to aspects of Chemistry which are required by their programs. For students who are majoring in Chemistry, the introductory courses serve as preparation for the Foundational courses.

Nationally, the introductory classes include a laboratory. This will be required by the ACS-CPT starting in 2014.

**Foundational courses – Reinforcement of Student Content and Skills Objectives.** The foundation course work provides breadth to Chemistry instruction. The ACS-CPT mandates that majors must have instruction equivalent to a one semester course of at least three credit hours in each of the five major areas of Chemistry – analytical chemistry, organic chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry. At the conclusion of a foundation course, a student will have mastered the vocabulary, concepts, and skills to pursue in-depth study in that area.

All Chemistry majors are required to take similar foundational courses. Their experiences might differ depending upon whether they take the traditional or Organic First curriculum, and which physical chemistry course they take as foundational (Chemistry 340, 341 or 342).

**In-depth courses – Enhancement of Student Content and Skills Objectives.** The curriculum for a Chemistry major must include at least twelve credits of in-depth work beyond the foundational courses. The in-depth courses build on the prerequisites of the foundational courses. The goals of in-depth courses are to integrate topics introduced in the foundational courses and to investigate these topics more thoroughly. Exams and other assignments are designed to encourage critical thinking and problem-solving skills.

Chemistry majors may take different in-depth courses depending upon their emphasis of study. Biochemistry majors, for example, are required to take Biochemistry I and II, where for other majors Biochemistry II might function as an in-depth elective.

Three courses are not directly associated with a single foundational field – Laboratory Safety, Polymer Chemistry, and Pharmacology. Laboratory Safety is a required course and an assessment venue for our Laboratory Safety professional skills learning outcome.

**Cognate courses.** The Chemistry major is a broad-field major, with requirements in Mathematics, Biology, and Physics. All Chemistry majors require two semesters of Physics with laboratory, Introductory Biology (Biology 150), and two to three semesters of Math including Calculus I (Math 166).
**Capstone.** The Chemistry major capstone experience consists of Chemistry 480 (Chemical Communications and Research) and Chemistry 495 (Undergraduate Research). Chemistry 495 is optional but encouraged.

Chemistry 480 is the student’s senior seminar. Students give a seminar to the department, based either on work they did for Chemistry 495 or on a literature topic. These seminars are evaluated by department faculty and other Chemistry students.

Since is a required course and comes at the end of the curriculum, Chemistry 480 provides an assessment venue for student content knowledge and professional skills.

**f. Out-of-classroom experiences and learning outcomes**

Chemistry, like other sciences, is by its nature a hands-on process. Students learn best by doing. Therefore the Chemistry curriculum has multiple opportunities for out-of-classroom learning, including laboratories, research, internships, international experiences, and Chem Demons.

**Laboratory.** Because of the hands-on nature of laboratory work and its value in achieving required student learning outcomes, the ACS-CPT requires 400 hours of laboratory experience (not counting the introductory sequence). This corresponds to approximately 10 laboratory credits, and must cover at least four of the five foundational areas of chemistry.

Students have some latitude in which laboratory courses they take, depending upon their program and their interests. All students are required to take laboratories in organic chemistry and analytical chemistry. Laboratory in inorganic chemistry will be required as we develop Chemistry 322 (Inorganic Chemistry), a new lecture/lab course. Depending upon the student’s program, from three to six credits of laboratory are electives required at the in-depth level.

**Research.** Students are encouraged (but not required) to engage in undergraduate research. Some students do their research here at UWRF, others do it over the summer at larger universities. In either case, this experience is an invaluable part of the student’s capstone experience.

**Internships.** Internships are uncommon in Chemistry but not unheard of. We have had several students who have recently accepted summer internships.

**International experiences.** In the past several years, two UWRF Chemistry students have gone to other countries (Italy and Germany) for undergraduate research experiences.

**Chem Demons.** UWRF Chemistry students (and students interested in chemistry) are able to work with the Chem Demons. This student group puts on chemical shows for local audiences including local schools. In the process of learning their demonstrations, the students have to learn about Chemistry content knowledge as well as presentation skills.
III. Assessment venues.

Department level assessment of learning objectives for university purposes are carried out at the two curricular levels—foundational and in-depth. Foundational level assessment is conducted after the core 200-level courses of Organic and Analytical Chemistry. In-depth assessment is conducted near the end of the student’s career, in the departmental safety course (Chemistry 261 – Laboratory Safety) and during the student seminar (Chemistry 480 – Chemical Communications and Research).

a. Venues artifacts for measuring learning outcomes and
b. Artifacts for measuring learning outcomes

Foundational level assessment.

Students finishing Organic II (Chemistry 232) and Analytical (Chemistry 250) are given standardized final exams which have been developed by the American Chemical Society’s Division of Chemical Education Examinations Institute. These exams are nationally normed.

For new exams, the Examinations Institute has been working to reference individual exam items to the ACS Curricular Concept Map. In the meantime we have mapped exam items to our content and skills learning objectives. Student exams are saved and then we will perform item analysis to see how our students perform on the different learning objectives.

Exam security and copyright prohibits us from publishing the mapping (as it would give students clues how to study). Exam mapping protocols are approved by the department Assessment Committee and kept by department faculty.

In-depth level assessment.

In-depth level assessment occurs in two venues— the departmental student seminar (two metrics, Diagnostic of Undergraduate Chemistry Knowledge exam and student presentation) and the Chemistry Laboratory Safety course, Chemistry 261 (one metric, student performance in class).

Laboratory Safety – Chemistry 261. This course was developed as the result of our last Program Prioritization. It is specifically designed to teach and to assess Professional Skills Outcome 4, Laboratory safety skills; the course learning objectives are identical to the desired programmatic outcomes. Because of this, the assessment metric is the distribution of student grades.

Student seminar – DUCK exam. The Diagnostic of Undergraduate Chemistry Knowledge (DUCK) exam is a nationally normed exam developed by the American Chemical Society Division of Chemical Education Examinations Institute. The exam is designed to assess student knowledge at the end of their career. It contains 10-12 scenarios, where students are asked 5-6 questions after each scenario. Students take the DUCK exam in the semester that they give their senior seminar (Chemistry 480). The assessment metric is student performance on the exam compared with national norms.
Similar to the foundational level exams, we have mapped DUCK exam items to the Content and Professional Skills learning outcomes. Student exams are saved and item analysis is performed to assess how students are performing on the various outcomes as compared to national norms.

Again, exam security and copyright prohibits us from publishing the mapping of exam items to learning outcomes. Exam mapping protocols are approved by the department Assessment Committee and kept by department faculty.

Student seminar – Presentation. Chemistry majors are required to give a seminar to the department (faculty and students) before graduation. Students develop and present a 30-minute seminar based upon laboratory or literature research. The seminar is evaluated by faculty and CHEM 480 students using the Chemistry Seminar Evaluation rubric presented in the appendices. The rubric provides a means of assigning a grade to the seminar and delivering feedback to the presenter. The rubric is used to assess Professional Skills Outcome 3, Communication skills.

c. Venues and Artifacts for out-of-classroom learning experiences.

d. Student Survey Feedback

Graduating seniors enrolled in Chemistry 480 complete a survey measuring 1) their perception of how the program’s learning experiences help them to meet their needs and 2) their satisfaction with the program. Details of the survey are presented in Appendix B – Student Exit Survey.

e. Alumni Feedback

Every three years, the program will send an electronic survey to students that have graduated in the past ten years. The survey will ask them about

- The relevance and effectiveness of the program in preparing them for their current position,
- What they see as trends in the Chemistry profession, and
- How the program could enhance its curriculum and learning opportunities.

f. Stakeholder Feedback
The American Chemical Society, through its Committee on Professional Training, represents external stakeholders and defines the parameters of a successful Chemistry program.

Every six years, the Department is required to submit a detailed report to the ACS-CPT for recertification. This report includes content and professional learning outcomes as well as the indirect measures of programmatic excellence of departmental faculty, instrumentation, resources, and staff. The department is required to provide copies of specific course syllabi, examinations, and student research reports.

If the ACS-CPT determines that the program meets the requirements for approval, the result is communicated to the Department and the chancellor or provost. The CPT communicates any recommendations for improvements.

If CPT determines that the chemistry program meets all of the requirements for ACS approval and the spirit of the guidelines, the Committee continues approval of the program. The Secretary of CPT reports this outcome in a letter to the chair of the department responsible for administering the ACS-approved chemistry program with a copy to the president of the institution (or chief administrative officer). The letter may contain CPT’s recommendations and suggestions for strengthening and further development of the chemistry program. The department must adequately address these recommendations as part of the next periodic review. Failure to do so may lead to a determination of noncompliance in the future.
IV. Process for Assessment

a. Assessment cycle

Student content knowledge outcomes are measured at three points:
- Twice during the student’s in-depth courses, at the end of organic chemistry (Chem 232 or 233) and at the end of analytical chemistry (Chem 250), through the administration of standardized exams in these classes.
- At the end of the student’s capstone experience before graduation, through administration of the DUCK exam.

Student professional skill outcomes are measured at different points depending upon the outcome:
- Laboratory knowledge outcome – at the same time as student content knowledge through appropriate questions on the three administered exams.
- Laboratory Safety outcome – In Laboratory Safety (Chem 261), typically taken during the student’s junior year.
- Communications outcome – During the student’s senior seminar, Chem 480.

b. Accountability for assessment process

The department assessment coordinator arranges for regular meetings of the assessment committee and oversees the compilation and distribution of documents to the department for review and the submission of plans and reports to appropriate parties (department chair, campus administration, etc.) on time. The department assessment committee prepares assessment plans and reports. The committee seeks input from members of the department during the process and submits all documents to the department as a whole for review and approval. During the development and revision phase of the process the assessment committee refers to documents made available by the ACS CPT and the results are made available to the ACS in the regular five year ACS accreditation review process.

c. Assessment process

The department assessment committee is responsible for the assessment process.
- Collection and review.
  - Individual faculty are responsible for administering the required standardized exams for content knowledge objectives.
  - The instructor for the Laboratory Safety course is responsible for ensuring that the course learning objectives and grading rubric match the departmental learning objective, and for administering the exam.
  - The instructor for Chemistry 480 is responsible for administering and collecting faculty and student evaluations of student seminars and for administering the DUCK exam to graduating students.
- Aggregation, analysis, and maintenance.
The departmental assessment committee is responsible for aggregation and analysis of the data.

The department chair, along with the department program assistant, is responsible for maintenance of the data.

Actions taken in response to the assessment are documented by the assessment committee.

d. Process for implementation of changes based upon assessment findings.

Results are presented to the department during an annual assessment meeting and during occasional (every several years) department retreats. Depending upon the results, the department may mandate curricular or other changes. Changes made over the past several years based upon assessment include:

- Introduction of an Organic First introductory curriculum,
- Development and implementation of a departmental lab safety course,
- Redesign of the program curriculum to give students more flexibility in course offerings,
- Redesign of the program’s capstone offerings (ongoing),
- Development of active learning strategies to engage students (ongoing), and

Most recent changes have been designed to include extensive evaluation. Changes are re-assessed by the assessment committee and the department during the departmental assessment meeting.

e. Location of assessment results and actions

Currently assessment results and actions are summarized in the minutes of the annual department assessment meeting, kept in the department office and available by request.

f. Additional narrative

Learning Outcome Rubrics – Seminar: The seminar rubric each faculty member completes is given below. Chemistry students who attend the seminar are also encouraged to evaluate their peers using the same rubric. Room is also provided on the form for comments:
Learning Outcome Rubrics – ACS Exams. Information about ACS exams and national norms can be found at the ACS – Division of Chemical Education – Exams Institute web page at http://chemexams.chem.iastate.edu/. We have identified individual exam items which map to the learning outcomes. These rubrics are stored in the Chemistry Department – including them here would violate exam confidentiality rules.

Learning Outcome Rubrics – Safety Course. Chemistry 261, Laboratory Safety, was designed to meet the Laboratory Safety learning outcome (the course learning objectives correspond to the departmental laboratory safety learning objectives). Student learning is assessed through exams and projects, including a paper and a presentation on a laboratory safety topic.

g. Accreditation and assessment standards

As discussed in the introduction, the Chemistry program at the University of Wisconsin – River Falls is approved by the American Chemical Society Committee on Professional Training (ACS-CPT). Program approval and accreditation is based upon student content knowledge.
(curriculum); student professional skills; program faculty, staff and budget, and program infrastructure. These correspond to the first four of the five listed department goals:

1. UWRF Chemistry degree recipients shall meet or exceed the standards in content knowledge expected by the American Chemical Society Committee on Professional Training (ACS-CPT).
2. UWRF Chemistry degree recipients shall meet or exceed the standards in student skills expected by the American Chemical Society Committee on Professional Training (ACS-CPT).
3. The UWRF Chemistry Department shall maintain program faculty, staff, and budget which meet national standards as outlined by the ACS-CPT.
4. The UWRF Chemistry Department shall maintain infrastructure which meets national standards as outlined by the ACS-CPT.

The CPT conducts two types of review: Annual and periodic. For annual review, the department must report to the CPT:

- the number of degrees granted by the program,
- whether graduates meet the ACS-CPT certification status, and
- supplemental information on the curriculum and the faculty.

Periodic review occurs approximately every five to six years. For the periodic review, the department is required to document all components of the ACS guidelines (which we have adopted as our learning outcomes). The department is required to provide copies of specific course syllabi, examinations, and student research reports.
V. Appendix A – ACS-CPT Student Professional Skills

Student Professional Skills learning outcomes are based upon the ACS-CPT publication Undergraduate Professional Education in Chemistry: ACS Guidelines and Evaluation Procedures for Bachelor’s Degree Programs (aka the Guidelines). Each learning outcome is referenced to the relevant section of the Guidelines and/or proposed changes in the Guidelines which are set for adoption in 2014.

We are responsible for demonstrating all of these outcomes to the CPT every six years during our periodic review process, by submission of student work and course syllabi. We are including only a subset of these requirements in our university assessment plan. It is our intent to add many or all of these objectives into our university assessment plan as we develop rubrics consistent with university (as opposed to CPT) requirements.

1. Laboratory Skills (Guidelines Section 5.5)
   a. Introductory courses must include significant hands-on experience (proposed revision).
   b. Students must have at least 400 hours of laboratory experience beyond the introductory level and must cover at least four of the five foundation areas of chemistry.
   c. The laboratory experience must include
      1) Synthesis of molecules;
      2) Measurement of chemical properties, structure, and phenomena;
      3) Hands-on experience with modern instrumentation, including
         1. Spectrometers (such as NMR, FT-IR, and UV-Vis)
         2. Chemical separations instruments, and
         3. Electrochemical instruments.
      4) Computational data analysis and modeling.
   c. (Proposed revision 2014) Students must have on-site and accessible at least one instrument from each of the following five categories
      a. optical molecular spectroscopy (e.g., FTIR, fluorescence, Raman, UV-Vis)
      b. optical atomic spectroscopy (e.g., atomic absorption, ICP-atomic emission)
      c. mass spectrometry (e.g., MS, GC-MS, LC-MS)
      d. chromatography and separations (e.g., GC, GPC, HPLC, capillary electrophoresis)
      e. electrochemistry (e.g., potentiometry, voltammetry)
   d. Students should understand the operation and theory of modern instruments and be able to use them to solve chemical problems.

2. Problem-Solving Skills (Guidelines Section 7.1)
   a. Using their knowledge of all chemistry subdisciplines, students should be able to
      1) Define problems clearly,
      2) Develop testable hypotheses,
      3) Design and execute experiments,
3. Chemical Literature Skills (Guidelines Section 7.2)
   a. Students should be able to use the peer-reviewed scientific literature effectively and evaluate technical articles critically.
   b. Students should learn how to retrieve specific information from the chemical literature, including the use of *Chemical Abstracts* and other compilations, with online, interactive database-searching tools.

4. Laboratory Safety Skills (Guidelines Section 7.3)
   a. Students should be trained in the aspects of modern chemical safety appropriate to their educational level and scientific need.
   b. Students should
      1) Understand responsible disposal techniques
      2) Understand and comply with safety regulations
      3) Understand and use material safety data sheets (MSDS)
      4) Recognize, assess, and minimize potential chemical and physical hazards in the laboratory
      5) Know how to handle laboratory emergencies effectively.

5. Communication Skills (Guidelines Section 7.4)
   a. Students should be able to
      1) Present information in a clear and organized manner
      2) Write well-organized and concise reports in a scientifically appropriate style
      3) Use technology such as poster presentation software, word-processing, chemical structure drawing programs, and computerized presentations in their communication.
   b. Chemistry is worldwide in scope. Although not required by the ACS, the study of a foreign language adds greatly to a student’s education.

6. Team Skills (Guidelines Section 7.5).
   a. Students should be able to
      1) Work effectively in a group to solve scientific problems
      2) Be effective leaders as well as effective team members
      3) Interact productively with a diverse group of peers.

7. Ethics (Guidelines Section 7.6)
   a. Students should
      1) Conduct themselves responsibly
      2) Be aware of the role of chemistry in contemporary societal and global issues.
      3) (Statements on sustainability and global responsibility will be added to the requirements in the 2014 revision.)

8. Capstone experience (proposed revision 2014)
   a. In a robust chemistry program, students must be provided with opportunities to synthesize the knowledge and skills provided across the curriculum. Mechanisms to accomplish this could include a capstone course or a substantive experience in an existing course or courses, as well as the opportunity for a mentored teaching experience, a seminar course that emphasizes student skills, or an independent research experience with a research report.
9. **Information management (proposed revision 2014)**
   a. Students must be instructed in data management and archiving, record keeping (electronic and otherwise), and managing citations and related information. This includes notebooks, data storage, information and bibliographic management and formatting (as exemplified by Papers, EndNote, Bibliotec, Nota Bene, etc.)

In addition to these curricular requirements, the CPT has other requirements pertaining to program faculty, staff, budget, and infrastructure. These items are also part of our six year periodic review.
VI. Appendix B – Student Exit Survey

Please fill in the circle that best reflects the extent to which you agree or disagree with the following statements:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can describe matter in terms of atoms, molecules and ions.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I had hands-on experience with modern chemical instrumentation (e.g. IR, NMR, UV-Vis, GC, GCMS, HPLC, etc.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I am able to retrieve chemical information using tools such as SciFinder, Reaxys, Google Scholar, PubMed</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>My problem-solving and critical thinking skills have improved as a result of the UWRF Chemistry Program</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<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>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>My scientific communication skills have improved as a result of the UWRF Chemistry Program</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oral (e.g. class presentation, seminar)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Written (e.g., paper, formal report, poster)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I worked on a project or assignment as part of a group or team as part of my UWRF Chemistry Program</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>