The University of New Mexico

Academic Program Review Self Study

CHEMISTRY AND CHEMICAL BIOLOGY

Fall/Spring 2020
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Criterion 1. Introductory Section & Background Information

The section should provide a brief introduction to the Self-Study Report, which includes the following elements:

1A: Summary An Executive Summary that provides a one to two-page summary/abstract of the information contained within the Self-Study Report.

Historically, the department has had several overlapping missions and goals: service teaching for science and engineering majors, professional training of chemistry majors and graduate students, and ambitions for a nationally-recognized research program. The Department of Chemistry and Chemical Biology (CCB) teaches ~3% of the student credit hours taught on main campus, and at one point had over 20 tenured and tenure track faculty and ~80 graduate students.

The department continues to teach a major service load; however, the number of research active faculty has fallen below the number expected for a major research university. The faculty numbers in CCB at UNM are consistent with the primarily undergraduate teaching universities in the Middle America State University Association (MASUA), and our numbers are well below other “flagship” state universities in MASUA (See figure below). However, in spite of the low faculty numbers, CCB faculty are performing at a very high level. For example, when comparing the total number of publications from MASUA chemistry department faculty, we are near the top when normalized to number of faculty (see figure below). Additionally, CCB faculty are publishing very impact work, with nearly 5,500 citations to CCB faculty publications in 2020 (average of 392 citations per tenure track faculty member)(data in section 6). We do not have the corresponding data for the MASUA departments, but we suspect we would be near the top in citations per tenure track faculty member. We strongly believe that the data in this self-assessment of the CCB department support the conclusion that CCB faculty are outstanding researchers and educators, however, it is imperative that the department hires 5-8 additional tenure track faculty as soon as possible.

Tenure track faculty numbers at Mid America State University Association (MASUA) chemistry departments.
Publication numbers from faculty numbers at Mid America State University Association (MASUA) chemistry departments. Blue bars represent total publications, yellow bars represent publications per faculty member.

Since we strongly believe that our faculty are truly outstanding, what has contributed to our low numbers? First, our building (Clark Hall) has needed major renovations since at least 1988. However, this problem is now corrected when phase 2 of the renovations are completed in summer 2021. In summer 2021, we will have a completely renovated building, with space to hold ~3 more active research groups, so we have space for growth, but space limitations will limit our growth. Therefore, we will require a new building to house a significant portion of CCB research labs if we are to reach our desired size of 20-25 tenure track faculty. Secondly, in the previous two decades, the department experienced governance issues that hampered smooth operations and led to a departmental atmosphere which does not necessarily focus on the common good. However, since Dr. Cabaniss became chair in 2012, these issues have mostly been resolved, and the department now has a supportive and encouraging environment that will allow assistant professors to thrive. CCB has hired seven new faculty over the last 3 years, and these researchers have brought new ideas and energy, and changes in the graduate program are underway.

We now have also significantly improved our teaching environment, which includes a Science and Math Learning Center (SMLC) that houses are general chemistry and organic chemistry laboratory facilities. Additionally, after the renovation of Clark Hall are completed, Clark Hall will provide modern utilities and refurbished teaching lab space for our upper division labs and new Chemical Biology teaching labs.

**1B: History** A brief description of the history of each degree/certificate program offered by the unit.

The modern version of the UNM Chemistry department (now the department of Chemistry and Chemical Biology) emerged in the 1980’s under the leadership of Riley Schaeffer. To quote W. Litchman’s departmental history, “Around 1980, the UNM chemistry faculty decided that to maintain currency in the mainstream of chemical education and research (with its trend towards biochemical specialties) a new direction in hiring, promotion, tenure, and pay was needed, one which emphasized the role of research over the role of undergraduate education as a determinant for tenure. To this end, they recruited a new
department chairman to implement these changes: Riley Schaeffer, who came from the University of Indiana with a significant reputation in research and graduate education. One of his first actions as chairman was to create a two-tier faculty: those who were significantly and successfully engaged in graduate education and research, and those who were more involved in the undergraduate curriculum. Emphasis on research productivity, funding, and graduate recruitment meant that departmental resources (funds, space, and personnel) were stretched tight, and caused friction through the following years.” Some faculty recall a decision to create two research foci: one in biological chemistry and one in materials. According to Litchman, in 1988 the department had “...22 tenure-track faculty members, plus lecturers, laboratory supervisors, and technicians.”

Litchman goes on to describe the 1990’s as a period in which successful hires of senior faculty (Christie Enke, Patrick Mariano, Debra Dunaway-Mariano, Hua Guo, Richard Kemp) were counterbalanced by a failure to keep overall faculty hiring even with retirements and departures, and the departures of several faculty who have since reached positions of distinction (including Vincent Ortiz, Thomas Bein, Su-Moon Park, Richard Crooks, Mark Hampden-Smith, Peter Ogilby and Carlos Bustamonte). By 2002, the department had only 18 tenure-track faculty, two of whom were partially committed to university service in the offices of the Dean of Arts and Sciences and the Provost.

The list of department chairs and graph of faculty numbers illustrate two of the problems that CCB has encountered since that time.

Table of Chemistry and Chemical Biology Chairs since 1988

Richard Willis Holder (1 Jan 1988 -- 31 Dec 1990)
Cary Jacks Morrow (1 Jan 1991 -- 30 Jun 1995)
Cary Jacks Morrow (1 Jul 2006 -- 30 Jun 2008)
Martin L Kirk (acting) (1 Jul 2008 – 30 June 2009)
David Bear (1 July 2009- July 15, 2012)
Stephen Cabaniss (16 July 2012 - 30 June, 2018)
Jeff Rack (1 July 2018 - 30 June, 2019)
Stephen Cabaniss (1 July, 2019 - 31 December, 2019)
Jeremy Edwards (1 January, 2020 - present)

Although CCB had only 3 chairs for the 15-year period 1991-2006, it has had 7 chairs in the 14-year period 2006-2020. This instability in the chair’s position started during an acrimonious period which began with a divisive failed search and which ended with the retirement of two analytical chemistry faculty (Enke, Niemczyk) and the departure of a third (John Engen). The remaining faculty voted not to make re-hiring into the analytical division a priority.

Morrow’s chairmanship of 2006-2008 (his second) was intended to allow the department to find and hire an external chair, but chair searches were not successful, and he was succeeded for one year (2008-2009) by Martin Kirk. During this time, the Provost and Dean, at the direction of the President, made a conscious decision to hire an external chair and dynamic young faculty to rejuvenate a shrinking department.

In 2009, the Dean of A&S appointed David Bear, a professor and former chair of Cell Biology and Physiology at the School of Medicine, as department chair. Bear set out to simultaneously reform degree programs, increase faculty numbers and improve laboratory facilities. Bear persuaded the university to make renovations to Clark Hall a top priority, and although a bond request for renovation funds was rejected in
the November 2010 election, he obtained several million dollars from the UNM Regents to upgrade labs and other space; the bond issue passed in 2012, and more extensive renovations were completed in 2016.

We are now undergoing the second phase of the renovations, which we anticipate will be the final renovation of lab space in Clark Hall. The state has invested over $34 million in renovations in the last 10 years.

During Bear’s chairmanship, three new faculty (Yang Qin, Chad Melancon and Fu- Sen Liang) started in CCB and two more (Ramesh Giri and Terefe Habteyes) were hired. However, of these faculty only Terefe Habteyes remains at UNM. Retention of our outstanding junior faculty has been a serious issue that has now been addressed, however, this situation needs to be closely monitored. The overall departmental environment has now significantly improved, and we do not anticipate departures going forward to be related to previous issues.

During the last 3 years, the department has hired seven new faculty, (Mark Walker, Yi He, Brian Gold, Christine Le, Susan Atlas, Dongchang Chen, and Justin Elenewski). This commitment of the College of Arts and Sciences to continue to support CCB is very encouraging. Of these, Christine left in 2020, primarily due to family reasons and the global pandemic. To encourage and support the junior faculty, the department has made significant changes to the graduate program to increase recruitment of top-quality graduate students. Additionally, the department has formed mentoring committees for the junior faculty to provide an encouraging and supportive environment for them to thrive.

The current chair, Jeremy Edwards, has been in office since January 2020.

1C: Organizational Structure A brief description of the organizational structure and governance of the unit, including a diagram of the organizational structure.
The department created a written handbook in the 2012-2013 academic year, which was drafted by the chair and senior faculty at that time. The handbook was discussed, modified as necessary, and approved section by section in a series of faculty meetings from September 2012 to February 2013. The entire handbook was approved April 3, 2013 (Appendix A). We continue to function according to this handbook.

The department has a chair, an elected ‘Faculty Advisory Committee’ of faculty, and a set of standing committees (graduate studies, undergraduate studies, etc.). It has two associate chairs, one for undergraduate studies and one for graduate studies. We do not have a formal mentoring committee for junior faculty, but the chair assigns 3 tenured faculty members as mentors for each junior faculty member.

The current faculty advisory committee (Drs. Martin Kirk, Mark Walker, Susan Atlas, and Diana Habel-Rodriquez) meets approximately bi-weekly. Dr. Joe Ho is the associate chair for undergraduate studies and Dr. Martin Kirk is the associate chair for graduate studies. Currently, all junior faculty have mentoring committees in place.

Standing committees for this year include the undergraduate committee chaired by director of undergraduate education Dr. Joe Ho, the graduate recruitment committee chaired by Dr. Martin Kirk, and the building committee chaired by Dr. Steve Cabaniss. This building committee is especially important now due to the second phase of extensive renovations of Clark Hall. Finally, we are in the process of forming a safety committee (to be chaired by Dr. Jeff Rack) to work with our chemical safety officer to ensure that best practices are applied in developing standard operating procedures within the research labs.
**1D: Accreditation** Information regarding specialized/external program accreditation(s) associated with the unit, including a summary of findings from the last review, if applicable. If not applicable, indicate that the unit does not have any specialized/external program accreditation(s).

The American Chemical Society (ACS) Committee on Professional Training (CPT) determines and publishes guidelines for undergraduate degree program approval and also reviews and approves programs from various departments. The complete ACS CPT document, “Undergraduate Professional Education in Chemistry” is included as Appendix B. The program approval guidelines cover a range of areas including the institutional environment, faculty and staff, infrastructure, curriculum, undergraduate research, specific student skills to be taught and program self-evaluation.

As noted in the CPT guidelines (page 1), “ACS authorizes the chair of the ACS approved program to certify graduating students who complete a bachelor’s degree meeting the ACS guidelines. Graduates who attain a certified degree must often complete requirements that exceed those of the degree-granting institution...” Thus, in contrast to some other disciplines and departments, completing a degree from an ACS-approved program does not guarantee an ACS-certified degree. This is the case for the B.S. degree from CCB. The ACS requires foundational work in 5 sub-disciplines of chemistry, including biochemistry, but CCB does not require a biochemistry course for graduation (it is an elective). ACS certification also requires 400 contact hours of chemistry laboratory beyond the general chemistry level, but B.S. requires only 330 contact hours (although this can be met by performing undergraduate research or taking the advanced synthesis lab).

The most recent periodic report for departmental approval was submitted to the ACS in 2020, and UNM CCB is currently an approved program.

In general, the CCB undergraduate program meets or exceeds ACS expectations for faculty and program size, resources and course offerings. However, a few of the requirements indicate a need for improvement:

Page 4- “The collective expertise of the faculty should reflect the breadth of the major areas of modern chemistry.”

- With a small faculty number, we are unable to cover the breadth of all areas of modern chemistry.

“Because faculty members serve as important professional role models, a program should have a faculty that is diverse in gender, race, and ethnic background.”

- The UNM CCB department, with no Hispanic or Native American members (and only three female tenure-track faculty), does not meet the diversity guideline. Additionally, with only 3 female tenure-track faculty, we consider this lack of diversity a problem.

Page 4- “Full-time, permanent faculty should teach the courses leading to student certification in an approved chemistry program. Programs may occasionally engage highly qualified individuals outside the regular faculty when permanent faculty members are on sabbatical leaves or to deliver special courses. The Committee strongly discourages, however, excessive reliance on temporary, adjunct, or part-time faculty in an ACS-approved program and will review such situations carefully.”

- Most sections of general chemistry (CHEM 1215 and 1225) and organic chemistry (CHEM 301 and 302) offered since 2014 have been taught by full-time lecturers. However, we have recently introduced an honors level general chemistry sequence, which has been taught by tenure track
faculty members. We intend that the honors sequence should be taken by Chemistry and Biochemistry majors.

Page 13- Original research culminating in a comprehensive written report provides an effective means for integrating undergraduate learning experiences, and allows students to participate directly in the process of science.

- While some of our students participate in undergraduate research, the percentage is relatively low and written reports have not been systematically documented by the department.

1E: Previous APR A brief description of the previous Academic Program Review Process for the unit. The description should:

§ note when the last review was conducted;
§ provide a summary of the findings from the Review Team Report;
§ indicate how the Unit Response Report and Initial Action Plan addressed the findings; and
§ provide a summary of actions taken in response to the previous APR.

The previous APR was conducted in 2013. The external review committee was Anne B. McCoy (The Ohio State University) and Peter M.A. Sherwood (University of Washington, Kansas State University, Oklahoma State University). The internal reviewer was Bernd Bassalleck (UNM, Department of Physics & Astronomy)

Below is a summary of the 2013 APR report.

Teaching
The reviewers noted that the department has a full range of teaching conducted by all faculty. Many of the undergraduate courses are taught by a dedicated team of instructors who are solely engaged in teaching at the undergraduate level. A concern is expressed below that tenure/tenure track faculty be more involved in teaching these courses than they currently are. This is being delegated too much to lecturers, their obvious talents and dedication to teaching notwithstanding.

The department teaches a large number of students in the first two years relative to the number of majors. The department should institute a smaller section of introductory chemistry for chemistry, biochemistry and chemical engineering majors. This will benefit the other programs as well as increase the number of majors.

There are a range of graduate courses, though we found that some graduate students found that there were challenges in getting the courses they needed. There may be merit in balancing the need for minimum course numbers with the importance in offering suitable courses to ensure that graduate students complete their necessary course work in a timely manner. A chronic problem with offering graduate elective courses is that they’re often officially under-enrolled, and yet the students clearly need them. A creative solution to this issue needs to be found at the College level.

There was real concern about the way in which teaching assistants were trained. While we commend the department for developing and implementing a training course, we share the concerns of many faculty as to whether teaching assistants need to be required to take this class each semester she or he is employed as a TA. Rather, the department may want to require enrollment in the class either the first semester or first year of a teaching appointment.
The BA/MD is well coordinated with the biology department. Biology seems satisfied with the chemistry part of this program. Chemistry is interacting well with engineering departments, particularly chemical engineering.

Assessments of the teaching programs are being conducted and the department seems committed to the assessment program. At some point we were told by a member of the upper administration that assessment reports had not been done. Upon further inquiry, we were given the impression that this particular problem rested in the College, and not in the department.

We do consider that the department is doing an excellent job in their offerings for the core program.

**Research**
The department has extramural funding that has varied around $2.5 million per annum for the past seven years (slightly less in 2012 - $2,282,845). This places it behind three other departments in the College of Arts and Sciences, namely Biology ($12,732,404 in 2012), Physics and Astronomy ($7,583,882 in 2012) and Earth and Planetary Sciences ($2,864,011 in 2012). This level of funding puts the department in the range of the fourth quartile of chemistry departments, though comparisons are complicated by the structure of chemistry departments nationally (which may or may not include biochemistry which generally attracts substantial NIH funding) as well as differences in the faculty size of departments. We do note that the current extramural funding is mainly received by a limited number of faculty. *The loss of key faculty (to retirement or moves to other institutions) could substantially impact the level of external support.*

We are concerned that the number of graduate students are falling (in contrast to the increase in undergraduate numbers). A department of 20 faculty who are directing graduate students should have a significantly larger number of graduate students than are currently enrolled (there were 45 graduate students enrolled in 2011).

We discuss below how the research activities of the department are impacted by cultural issues, by space and facility issues, and by issues related to retention and faculty size and morale.

**Service**
Faculty in the department are contributing to service in the university, the community and in their discipline. We do note the concern that the fraction of the faculty involved in administrative roles is detrimental to the department’s research activities and the overall performance of the department.

**Principal Observations**
Our *major observations* can be summarized in the following three points:

1) There is a *serious culture problem* in the chemistry department.

2) *The size of the faculty is too small.*

3) *Inadequate infrastructure, resources and space,* affecting both of the above issues.

**Immediate Issues**
*The Challenge*: New chemistry laboratories have been constructed across the country in recognition of the need to provide safe working conditions for chemical research and teaching and to accommodate modern instrumentation. A number of universities have spent considerable amounts of money to upgrade existing buildings, but in the end the cost of updating existing buildings has proved prohibitive and the disruption to
the research activities during these upgrades has been especially damaging. Numerous challenges arise from attempts to upgrade existing buildings, for example the ducting and pumping systems on hoods have a limited life expectancy and can be subject to sudden failure. Attempts to upgrade hood systems in older buildings can be especially challenging because of various factors such as the need to have an effective “make-up” air system which is best in the form of a centralized rather than a localized system. We discuss this further below when we comment on the eventual need for a new building.

Renovations: We were pleased to see that the bond issue was finally funded to provide renovations of Clark Hall, but that is not enough as the current building is not appropriate for modern instruments. In addition, there are deficiencies in the current building that raise serious safety and compliance concerns.

Staff: The current professional staff is inadequate to support the department’s research efforts.

Major Shared Instrumentation: Chemistry departments need major shared instrumentation such as nuclear magnetic resonance spectrometers, X-ray diffractometers, and mass spectrometers. Such instrumentation is often obtained by departmental proposals to major funding agencies such as the National Science Foundation and the Department of Defense. Such proposals almost always require matching funds, and the institution needs to be prepared to provide these funds in order for the department to be viable in the future.

Large Interdisciplinary Proposals: The chemical sciences are often key players in large interdisciplinary proposals, and these proposals frequently require matching funds – again the university needs to develop a plan to provide these matching funds.

Innovative Solutions

We strongly recommend that the department look at the proposed interdisciplinary laboratory space extension to the new physics and astronomy building for additional space. It may be necessary to find temporary laboratory space to grow the department to the minimum 20 faculty, and this space may need to be in other departments or off campus.

Long Term Solutions

In the long-term the university will need to work with the department on a solution which addresses a number of issues. These issues include looking at the use of interdisciplinary space while seeing how best to retain an identity for a chemical sciences program. Practical space issues in many universities have led to faculty in departments working in various widely separated locations on and off campus, and while there are some significant advantages in such developments, there are also issues arising from the dispersal of a department’s faculty and a reduction in the interaction between departmental faculty. In the long-term a new building is needed for the department, and such a development will have many benefits including safety, space for growth, improved faculty morale, better recruiting for graduate and undergraduate students, and an ability for the department to better serve the university.

Leadership and the Future of the Department

We submit our report at a time when the department is undergoing a major transition. Thus, some of our comments reflect on prior practices, so what happened during the last three or four years under Dr. Bear is not necessarily relevant moving forward. Having said that, the successful hiring of several new faculty and the ultimately successful push for resources to renovate Clark Hall under the previous Chair were clearly very important positive developments.
The department should develop a new strategic plan under the leadership of the new Chair. The department should also look to involving alumni and seeking additional financial support from their graduates. We recommend that the department evaluate the merit of establishing an external advisory board.

It is our distinct impression that Steve Cabaniss is off to a very good start as Chair, a very challenging job indeed in that department at the current time. We consider it crucial that the upper administration provide Steve with as much support as possible. Along the lines of faculty morale and improving the departmental culture, we encourage the entire upper administration to meet with the faculty and show that there is indeed support for the chemistry program. This program is simply too important for a research university.

As the department moves into the future it is important that the department feels that it is fully participating in the development of the departmental future and it is doing so with the full support of the administration.

The support from the university and the full participation of the department will see the department grow into an outstanding department that fully serves a major national research university.

**1F: Vision & Mission**

Provide a brief overview of the vision and mission of the unit and how each degree/certificate offered addresses this vision and mission. Describe the relationship of the unit’s vision and mission to UNM’s vision and mission. In other words, to assist the university in better showcasing your unit, please explain the importance of its contribution to the wellbeing of the university, including the impact of the unit’s degree/certificate program(s) on relevant disciplines/fields, locally, regionally, nationally, and/or internationally?

The CCB departmental mission statement reads:

“The primary mission of the Department of Chemistry and Chemical Biology is to deliver a quality education to traditional and nontraditional graduate and undergraduate students in the College of Arts and Sciences, and to the University at large. The Department provides a robust educational environment that fosters the acquisition of chemical knowledge and the use of chemical principles to give students deeper insight into understanding how Chemistry will play a fundamental role in molecular science discovery and the development of new technologies in the 21st century. Therefore, we view Chemistry as the central science, and the Department as a community of scholars whose research and educational activities focus on understanding the fundamental properties of materials, and chemical and biological reactions at the molecular level. The faculty is committed to the development of a nationally prominent and internationally recognized graduate research program. This program will be fully engaged in efforts to ensure success of the mission. To this end, the Department will actively seek mutual partnerships with the University community, the National Laboratories in New Mexico, and the greater national and international scientific communities in order to fully contribute to the fundamental molecular science needs of our society.”

This departmental commitment addresses all four points of the UNM mission statement (Appendix C), by (1) offering undergraduate and graduate educational programs, (2) emphasizing a graduate research mission, (3) partnering with the scientific community locally and nationally to serve the public of New Mexico, and (4) providing training and research support for the fields of medicine and public health in New Mexico.
Criterion 2. Teaching & Learning: Curriculum

The unit should demonstrate the relevance and impact of the curriculum associated with each degree/certificate program. (Differentiate for each undergraduate and graduate degree and certificate program offered by the unit.)

2A: Curricula Provide a detailed description of the curricula for each degree/certificate program within the unit.

§ Include a description of the general education component required, including any contributions from the unit to general education, and program-specific components for both the undergraduate and graduate programs.

§ Discuss the unit’s contributions to and/or collaboration with other internal units within UNM, such as common courses, courses that fulfill pre-requisites of other programs, courses that are electives in other programs, cross-listed courses, etc.

The published learning goals of CCB’s Bachelor of Arts (B.A.), Bachelor of Science (B.S.) and Master of Science (M.S.) degrees (Appendix D) dated from 2017 are listed below.

Ph.D.

1. Develop a broad understanding of the major areas of chemistry with an understanding and awareness of the professional, ethical and safe applications of their knowledge.
   a. Possess broad factual knowledge at an advanced level in multiple areas of chemistry.
   b. Actively participate in weekly departmental seminars

2. Acquire a significant and deep-rooted knowledge in their chosen sub-discipline in chemistry.
   a. Learn subject specific content such as synthesis and characterization, reaction mechanisms, thermodynamics, quantum mechanics, kinetics, spectroscopy, equilibrium and quantitative methods
   b. Attend divisional student seminars in their chosen area of chemistry

3. Report, present and/or publish the results of their research and independently solve research problems.
   a. Present independently researched topics in their divisional seminar
   b. Publish their research findings in peer reviewed scientific journals with their research advisor(s)
   c. Independently solve research problems
   d. Critically analyze their own results and the results of others, including published literature
   e. Prepare, present and publically defend their research project at a formal research proposal (RP) and dissertation defense.
   f. Write a coherent dissertation covering their specific contributions to the discipline of chemistry
4. Be prepared for entry into academia or industry.
   a. Be members of at least one professional scientific organization
   b. Engage in collaborative research with other scientists in their field
   c. Solve research problems independently or as a small team

### M.S.

1. Develop a broad understanding of the major areas of chemistry with an understanding and awareness of the professional, ethical and safe applications of their knowledge.
   a. Possess broad factual knowledge at an advanced level in multiple areas of chemistry
   b. Actively participate in the weekly departmental seminars

2. Acquire a significant and deep-rooted knowledge in their chosen sub-discipline in chemistry.
   a. Learn subject specific content such as synthesis and characterization, reaction mechanisms, thermodynamics, quantum mechanics, kinetics, spectroscopy, equilibrium and quantitative methods
   b. Attend divisional student seminars in their chosen area of chemistry

3. Report, present and/or publish the results of their research and independently solve research problems.
   a. Present independently researched topics in their divisional seminar
   b. Publish their research findings in peer reviewed scientific journals with their research advisor(s)
   c. Write a coherent masters thesis or written final project covering their specific contributions to the discipline of chemistry

4. Be prepared for entry into academia or industry.
   a. Be members of at least one professional scientific organization
   b. Engage in collaborative research with other scientists in their field
   c. Solve research problems independently or as a small team

### B.A.

1. **Content Mastery:** Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry

2. **Communication Skills:** Convincingly present scientific data and arguments in an oral and written format

3. **Professional Development:** Be prepared for entry into professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service
B.S.

1. **Content Mastery:** Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry

2. **Lab Skills:** Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods

3. **Communication Skills:** Convincingly present scientific data and arguments in an oral and written format

4. **Professional Development:** Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc.) or the chemical industry or government service

The MS degree further emphasizes a significant and deep-rooted knowledge of a sub-discipline within Chemistry and Chemical Biology. The Ph.D. degree emphasizes both a deep-rooted subject knowledge and the ability to plan and carry out independent research in chemistry. The assessment plan and learning goals for the Ph.D. were modified in January 2009, but have not been approved or published. The lack of approval may be due to the numerous changes the program has undergone in the last four years (see section III below).

The difference between the B.S. and the B.A. degree lies in research experience. We expect students with a B.S. degree in chemistry to be research chemists whereas those pursuing a B.A. degree bench chemists. Therefore, such difference is reflected in the program goals where Lab skills are included in the B.S. degree goal but not in the B.A. degree. Furthermore, students in the B.A. degree will have more flexibility to take other courses such as biology for their career. As the result, many students choose a Chemistry B.A. degree for their preparation of the application to medical or pharmacy schools.

These goals are typically presented to the students within the CCB curriculum through syllabi, course learning objectives and course assessment (tests, lab reports, etc.).

The Department offers many General Education courses to serve a wide variety of students on UNM campus. At the freshman level, there are developmental courses for students without strong high school preparation: CHEM 1105, for students without prerequisite requirements, and 1106, for students qualified for the regular General chemistry course but are at risk to fail. CHEM 1110 is a “Chemistry in the Communities” course for non-majors to gain an insight of the applications of chemistry in the society. The CHEM 1215, 1215L, 1225, and 1225L courses form the regular General Chemistry sequence for STEM majors, with a typical annual enrollment of 2000 students and serving more than 50 STEM and non-STEM majors. The CHEM 1217 and 1227 research-focused General Chemistry sequence serves Chemistry-focused fields. CHEM 1120C is the General Chemistry course for Allied Health majors.

The Department has many topic courses: CHEM 457 (Environmental Chemistry), 468 (Chemistry and Physics at Nanoscale), 469 (Characteristic Method of Nanostructure) and 471 (Advanced Topics) These serve students from multiple academic programs and are the result of collaboration between Chemistry and Chemical Engineering faculty. The CHEM 1215/1217 series also serves as a pre-req requirement for many other programs on campus and is required by 28 UNM degree programs in their program requirements. These courses have been one of the core courses for professional school admission requirements.
2B: Mode of Delivery Discuss the unit’s mode(s) of delivery for teaching courses.

CCB offers two undergraduate degrees, the B.A. and B.S., and two graduate degrees, the M.S. and Ph.D.

The undergraduate degree requirements follow the traditional pattern of many ACS-certified chemistry degrees, and are specified in Appendix D, which also includes sample 4-year plans for graduation. For both the B.A. and the B.S., students must fulfill the UNM general education requirements, and pass one year of calculus and one year of calculus-based physics, two semesters each of General Chemistry plus lab and Organic Chemistry plus lab, and one year of quantitative analysis plus lab. The B.A. degree, which is intended for pre-professional students (mostly medicine and pharmacy) and students with a strong interest or double major in biology, further requires a single semester of physical chemistry emphasizing biological systems and 7 hours of approved electives (the biologically oriented courses CHEM 421 and 425 are often selected for this, since they meet the UNM medical school’s matriculation requirement). The B.S. degree requires a two-semester calculus-based physical chemistry sequence with one semester of lab, a senior-level inorganic course, advanced lecture/lab courses in chemical instrumental analysis and 4 credit hours of approved electives.

The graduate program requirements are currently in a state of flux. The most recent graduate handbook (Appendix E) requires that students take four “core courses” from a list of 5, perform a laboratory rotation to select an advisor, and take an individualized, literature-based written candidacy exam. The graduate committee is currently re-writing the graduate handbook, which the faculty will review and approve later in the spring 2021 semester. The new graduate program handbook will change the coursework requirements, advisor selection procedures, and may also change the written and oral candidacy exams. A complete draft of this new handbook should be available by the time the review committee convenes at UNM.

CCB teaches courses required by other science and engineering programs, which increases enrollment far beyond that needed for chemistry majors alone. Physics and most engineering majors require the general chemistry sequence (CHEM 1215 and 1225) with lab (1215L and 1225L). Biology, biochemistry and chemical engineering majors are also required to take the organic chemistry sequence (CHEM 301 and 302) with lab (303L and 304L). Chemical engineering and biochemistry majors also take one semester of physical chemistry (CHEM 311 or 312), and many of the biology majors opt for a minor in chemistry which typically leads to enrollment in quantitative analysis (CHEM 2310C) and/or physical chemistry (CHEM 315).

To provide preparation for students who will need more in-depth knowledge of general chemistry to participate in undergraduate research, the department has redesigned the honors general chemistry sequence, CHEM 1217 and 1227, to be research focused. Guest lecturers are invited from National Labs, UNMH, and other UNM departments to teach students in the classroom. This course recruits students from chemistry, biochemistry, and chemical engineering majors. To increase the effect of early preparation of freshman students, we also redesigned the general chemistry lab sequence (1215L and 1225L) to be based on course-based undergraduate research experience (CURE). In 2020, the 1215L and 1225L courses went through a major redesign as part of the NSF Expanded CURE (ECURE) project. Certain research elements (experimental design, research ethics, scientific argumentation, etc.) were integrated into the course curriculum for freshman students to learn and practice. Due to the COVID-19 limited operation, ECURE was also piloted in remote teaching (Appendix F). The CURE has also been piloted on senior lab courses such as CHEM 453L.

CCB also teaches two service courses intended for allied health majors: nursing, physical therapy, etc. The first semester (CHEM 1120C) is a 4-CH survey of general chemistry topics. The second semester (CHEM 2120) is a 3-CH combined organic and biochemistry course. These courses are not recommended to either
A&S science majors or to majors in non-health-related fields, although CHEM 1120C can be counted toward the UNM general education requirement.

The department has begun to offer a course targeting non-science majors. The course (CHEM 1110) would use the ACS textbook “Chemistry in Context” which teaches chemical concepts, scientific literacy and critical thinking through an unusual curricular approach. Unlike traditional textbooks, which are organized by chemical concept (one chapter on reaction kinetics, one chapter on photoprocesses, etc.), “Chemistry in Context” is organized by macroscopic issues or problems (the ozone hole, energy and alternative fuels, etc.). Chemical concepts are taught by repeated exposure in multiple contexts throughout the semester, rather by in-depth coverage over a 1-3 week period. This course commenced in Spring 2014.

After many years of study on the keys to student success in the General Chemistry courses, we went through course redesign for CHEM 1215, 1225, 1217, and 1227 between 2012 and 2017. Student pass rates have improved from 60% to 80% in CHEM 1215 and 1225. Recently, we introduced the ALEKS Chemistry Placement test to replace the outdated pre-requisite requirements for these courses. The new placement system is scheduled to be in place in the summer of 2021.

The Department has offered selected General Education courses online in the past for the preparation of General Chemistry and Organic Chemistry I. In 2020, in the wake of COVID-19 pandemic, the Department expanded its online course list to offer a complete sequence of General Chemistry for STEM Majors, CHEM 1215, 1215L, 1225, and 1225L. The targeted students for these fully online versions are not only those who must take their education online, but also students whose fields do not require extensive Chemistry knowledge and lab experiences, such as selected Engineering fields or social sciences.
Criterion 3. Teaching & Learning: Assessment

The unit should demonstrate that it assesses student learning and uses assessment to make program improvements. In this section, the unit should reference and provide evidence of the program’s assessment plan(s) and annual program assessment records/reports. (Differentiate for each undergraduate and graduate degree/certificate program and concentration offered by the unit.)

3A: Assessment Plans

Provide current Assessment Plan for each degree and certificate program in the unit.

Systematic assessment plans were designed and approved for the B.A., B.S. (Appendix G), and we are initiating M.S. and Ph.D. degree programs plans (2009 plans are in Appendix G). The three-year cycle of the plans for B.A. and B.S. have been carried out since 2009 by a Departmental Undergraduate committee. The graduate committee has been re-initiated (chaired by Dr. Martin Kirk), and no record of M.S. and Ph.D. program assessment can be found. The graduate committee has been charged with implementing an assessment plan going forward.

The B.A. and B.S. Program Assessment plans are on a three-year cycle to cover all Student Learning Outcomes (SLO) of the programs. Each year, selected Student Learning Outcomes (called priority SLOs) were assessed by collecting student performance measures from the pre-selected courses and exit interview for graduates. The direct measures could be one or a combination of the following: in-class quizzes, worksheets, exams, other student artifacts, and pre- or post-class assignments. The indirect measures are surveys or exit interviews. The assessment data were collected by faculty members who taught the selected courses and analyzed by the Undergraduate Committee (UGC) members. The results of the analysis were then reported to the CAS and disseminated to all faculty at CCB and Teaching Assistants.

Each year, recommendations for changes to the programs were made by all faculty and summarized by UGC in the assessment reports. The changes were then reported in the subsequent Program Assessment reports in December (Appendix G for the summary from 2014-2020).

3B: Assessment Reports

Provide current Assessment Report for each degree and certificate program in the unit. Expand on any initiatives/changes that have resulted from these reports.

The annual Program Assessment reports for B.A. and B.S degree programs have been submitted to CAS since 2014. The most recent reports for Year 2019-2020 are attached in Appendix H. The reports from Year 2014 are also attached for reference.

CCB faculty have pursued a variety of strategies to improve pedagogy and student learning, particularly in lower level courses. The following examples are the direct or indirect results of our yearly assessment efforts. Some examples have been briefly mentioned in the “Curriculum” section.

General Chemistry labs (1215L and 1225L) were redesigned in 2018 by Dr. K. Joseph Ho to include course-based undergraduate research experience (CURE) for freshman STEM students to be engaged in real world practices of a Chemist’s laboratory work and prepare them for more involved Faculty mentored undergraduate research. The new CURE CHEM 1215L and 1225L are also part of University’s NSF Expanded CURE (ECURE) project launched in 2020. In this ECURE, students are guided to design experimental procedures, practice basic lab techniques in context and learn to make appropriate scientific arguments from experimental results. From student’s performance data of 2018 and 2019, students with full CURE outperformed students with partial or no CURE by nearly 100%.
CCB has also introduced a “parachute” mechanism into General Chemistry I (CHEM 1215) which encourages students who fare poorly on the first test or two in CHEM 1215 to move into a smaller section to review fundamentals (designated CHEM 1106). These “parachuted” students thus remain enrolled in a science course and receive additional preparation to improve their chances of passing CHEM 1215 should they retake it. Preliminary data from 2010-2012 shows that “parachuted” students have significantly greater chances of re-taking and passing CHEM 121 than students who remained in CHEM and received a W or F.

The lecture portion of General Chemistry for STEM majors (CHEM 1215, 1225, 1217, and 1227) were also redesigned from 2012 to 2017. All these courses employed active learning pedagogy, whereas the CHEM 1217 and 1227 sequence focused on Research led by Prof. Hua Guo. This project, sponsored by the UNM Office for Support of Effective Teaching (OSET) and Title V for Gateway Course Redesign, has shown promising improvements in student learning (Appendix I). Dr. Sushilla Knottenbelt, Director of the BA/MD program, worked with the Associate Provost for Curriculum to develop a campus-wide program for Peer Learning Facilitators (PLF) to continue supporting our Active Learning in General Chemistry Courses (Appendix N).

A new Placement system using the ALEKS Chemistry program is being implemented to replace the outdated pre-requisite requirements of our freshman chemistry courses. This is the result of nearly ten years of research and development about the best preparation of freshman students for General Chemistry courses led by Dr. Ho. The result of these studies indicated Math test scores do not provide an effective predictive power for our students’ course performance in general chemistry (evidence attached). A predictive model was generated based on ALEKS data collected from 2014-2015. Student performance data from 2000 to 2015 show that almost 90% of students from ALEKS receive a passing grade (A, B, or C) and that 7% of D, F, and W students would have received a passing grade if they had practiced ALEKS for three weeks (attached evidence). The pre-semester ALEKS also reduced the performance gaps from the first-generation students and between genders by as large as 94-95%, and there were various performance gap reductions between different ethnic groups. The new ALEKS placement system is expected to be implemented in the summer of 2021.

3C: Primary Constituents
Describe the unit’s primary constituents and stakeholders. Include and explanation of how the student learning outcomes for each degree/certificate are communicated to students, constituents, and other stakeholders.

The department of Chemistry and Chemical Biology serves a variety of often-interrelated groups both on- and off-campus. On-campus constituencies include: the general undergraduate student body, through general education courses; the science and engineering majors who require CCB service courses as part of their degrees; the chemistry majors who rely upon CCB for upper division coursework and academic and career, advising; CCB graduate students who rely upon faculty for advanced coursework, research support and professional training; and our colleagues in other UNM departments whose research programs rely upon our chemical expertise, student training and specialized facilities. Off-campus constituencies include: the people of the Albuquerque area and New Mexico at large who rely upon access to chemical expertise in public matters; chemical educators in NM secondary schools and UNM branch campuses who rely upon our department for guidance in curriculum and standards in their courses; NM community colleges, whose students will transfer to UNM to complete their degrees; local and NM industries that may employ CCB graduates and/or require advanced technical expertise or facility access; and the national and international science communities, which rely upon UNM (and other schools, of course) to produce the trained professionals and the research-derived knowledge that these communities employ.

CCB faculty lead and participated in a number of outreach and community activities. In Albuquerque, faculty (Ho, Depperman, Whalen) work with local schools to provide lab access and demonstration and
provide expertise on local environmental problems like the Kirtland AFB jet fuel plume (Cabaniss). Statewide, the department’s summer workshop for high school chemistry teachers (Ho) has helped improve secondary instruction. Nationally, faculty organize symposia and edit prominent scholarly journals (e.g., Guo, Kirk). These activities show how chemistry and CCB integrate with the intellectual and civic life of New Mexico and the nation.
Criterion 4. Students (Undergraduate & Graduate)

The unit should have appropriate structures in place to recruit, and retain undergraduate and graduate students. (If applicable, differentiate for each degree and certificate program offered by the unit). Include specific measures and activities aimed at increasing equity and inclusion.

4A: Recruitment Discuss the unit’s proactive recruitment activities for both undergraduate and graduate programs, including specific efforts focused on recruiting students of color, underserved students, and students from groups that have been traditionally under-represented in your academic field.

Between Fall 2012 and Fall 2018, students in all levels of Chemistry courses were invited to attend an orientation session held in conjunction with the College of Arts and Sciences Advisement staff, always scheduled on a weekday afternoon. Recruitment fliers were posted and the event was catered. CCB Lecturer Lisa Whalen typically organized each session, introduced the various speakers and discussed scholarship opportunities. Fliers were sent to CCB faculty who were asked to invite all of their students in all of their courses, especially freshmen. All CCB faculty were invited to introduce themselves to students and slides describing each faculty member’s research were included. A typical agenda included presentations from the Lobo Chemistry Club (the UNM American Chemical Society Student Affiliate), the Center for Academic Program Support, Career Services, the Pre-Health Sciences Program, the Minority Access to Research Careers Program, the Initiative for Maximizing Student Development, the Ronald McNair Scholars Program, and the UNM Secondary Education Program. CCB Professor David Keller talked specifically about the American Chemical Society, undergraduate research opportunities and upper division courses. Faculty teaching these courses were invited to attend and introduce themselves. These orientation sessions were held once every semester with limited participation by CCB faculty, all CCB advisement staff, and the CCB Undergraduate Advisory Committee until November 2018. Student attendance at the orientation sessions was not very high; perhaps 20 students at the most attended.

In Fall 2018 CCB Chair Jeffrey Rack encouraged the development of a Chemistry Open House, to be held on a Friday afternoon in January 2019. This format was significantly different from the orientation sessions, and Albuquerque Public Schools high school chemistry teachers were included in the invitation. One drawback that immediately came up was the lack of available parking at UNM for high school students wishing to attend. The open house began with a reception and introduction by Prof. Rack with an explanation of the format. Throughout the building, CCB faculty and staff were stationed in different rooms to talk to students about graduate school and the application process, undergraduate research, and instrumentation and lab facilities. In one room, CCB Prof. Yi He set up a computer demo of his research. In another room, CCB faculty and College of Arts and Sciences CCB advisors discussed the undergraduate degree curricula and upper division electives. The most popular room was staffed by CCB alumni currently working locally (Sandia National Labs, APS, Lovelace Respiratory Research Institute, NTxBio) and representatives of local companies (AMRI). CCB graduate students gave tours of the building and lab facilities. Open house attendees could join a tour or go into any one of the rooms at any time to talk about these topics. Records indicate 37 people attended and it was well received.

Students who attended were not asked to identify their gender, race or ethnicity. There is no data on how many students of color, underserved students, or students traditionally underrepresented in Chemistry attended. Guessing from names alone, thirteen women and eleven Hispanic students attended.

No events for recruiting undergraduate students were organized for Fall 2019 or Spring 2020 after the change in CCB leadership in July 2019 and disruption due to the COVID-19 pandemic in March 2020.
**4B: Admissions** Discuss the unit’s admissions criteria and decision-making processes (including transfer articulation(s)) for both undergraduate and graduate programs. Evaluate the impact of these processes on enrollment.

UNM Students can enter the BA or BS Degree program after completing the UNM College of Arts and Sciences Communication, Math, and Second Language general education requirements. The Communication requirement consists of 6 credit hours (English 1120 and one other course chosen from options). The Math requirement is 3 credit hours (Math 1430 or 1512, Calculus I). The Second Language requirement is 3 credit hours of a course in one of the regular language departments at UNM. Overall students must have earned 26 credit hours and have a 2.0 GPA. For Chemistry, specifically students must also have completed Chemistry 1225/1225L (General Chemistry II and Lab). There are no other separate admissions criteria for students set up by CCB.

Transfer articulation for courses already entered in the admissions database ([http://admissions.unm.edu/future-students/transfer/transfer-equivalencies.html](http://admissions.unm.edu/future-students/transfer/transfer-equivalencies.html)) is done automatically by UNM admissions staff. Transfer articulation for courses not in the database is handled by the Chemistry Advisement staff, CCB Lecturers Lisa Whalen and K. Joseph Ho, and CCB Program Coordinator Karen McElveny. Students follow a process by which they send evidence of the course’s requirements and material covered (Syllabus, textbook and chapters, schedule of lectures, etc.) and a written statement of the purpose for the request to chemadvise@unm.edu. For Chemistry 1215/1215L/1225/1225L/2310C, the materials are checked by Chemistry Advisement and forwarded to K. Joseph Ho, who evaluates for equivalency. For Chemistry 301/302/303L/304L, the materials are checked and forwarded to Lisa Whalen, who evaluates for equivalency. For courses numbered above Chem 304L, the materials are checked and forwarded to Karen McElveny, who then communicates with the appropriate faculty member who can evaluate for equivalency. There are very few requests for transfer articulation at these course levels above Chem 304L.

All of these processes have little influence on course enrollment. The most important transfer articulation process that does influence enrollment occurs automatically when students transfer from CNM to UNM. CCB graduate students can enter our program via three separate programs [Ph.D.; MS(track 1); MS(track 2)]. Specific instructions for admission into our program are detailed in Figure X. Our application deadline for Fall admissions is January 15 of the same year. The Graduate Admissions Committee meets regularly to develop admissions policy, assess the status of the graduate program, review graduate applications, and accept qualified students into our program.

Figure of CCB Graduate Application Guidelines.
## Test Scores

A B.S. or equivalent degree in Chemistry or closely related discipline is required by the time of the start of graduate studies. The minimum undergraduate GPA is 3.0.

A minimum TOEFL score of 79 (internet based) or 550 (paper based) is required. Alternatively, an IELTS score of 6.5 or higher is required. Official test results must be sent directly to the University of New Mexico. The TOEFL code for UNM is 4845.

GRE is not required but recommended.

## Letter of Intent

Required. Please indicate which area you are interested in:

- Biological Chemistry/Chemical Biology/Medicinal Chemistry
- Catalysis and Synthesis
- Physical Chemistry/Energy/Materials

## Writing Sample

Optional. No special instructions.

## CV/Resume

Required. No special instructions.

## Recommendations

Three (3) letters of recommendation are required.

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### 4C: Data

*Provide available data and an analysis of the unit’s 1) enrollment, 2) retention, and 3) graduation (i.e. time to degree, graduation rates, etc.) trends. Please provide data and analysis on enrollment, retention and graduation rates for students by race/ethnicity, gender, first generation, and Pell grant status, where possible. Include an explanation of the action steps or initiatives the unit has taken to address any significant challenges or issues highlighted in these trends. When possible, data should be obtained from a UNM source such as MyReports or OIA. The APR office will assist with identifying appropriate data sources.*
The department plays a central role in educating UNM undergraduates. CCB teaches a very large service load of undergraduates majoring in science, engineering and the allied health sciences. In AY 2016-2017, CCB taught over 19,000 student credit hours (19,761), or over 5.5% of the SCH taught on main campus. Lower enrollment across the University has resulted in a steady decrease to 15,912 CH since reaching the peak in 2015-2016.

The number of BA and BS degrees awarded by CCB has not changed significantly in the last 5 years, remaining around 25 BA degrees and 10 BS degrees per academic year. (Note: the departmental BA count includes all BA double-majors and not just those who listed CCB first on the graduation form, which differs from OIA and A&S counting statistics). Discerning historical trends in undergraduate degrees is problematic, since the UNM OIA (Office of Institutional Analytics), UNM A&S (College of Arts and Sciences) and ACS databases are not mutually consistent.

Bachelor of Arts degrees awarded by CCB
Bachelor of Science degrees awarded by CCB

Graduation rates for BA and BS majors do not follow a steady trend, except that they are consistent with the time to degree of 5.1 years. The students with entry year 2014 had unusually high graduation rates. Those who began in 2016 are following a similar trend. Male graduation rates lag consistently behind female graduation rates. Graduation rates for Hispanic students do not differ significantly from the rest of the population except for the entry year 2012 students. Female student graduation at 5 years seems to be more predictable and consistent in the last five years.

Graduation Rates for Chemistry and Pre-Chemistry Majors, 2015-2019 (OIA data)
Retention rates at the third semester of enrollment do not vary widely by ethnicity or gender and have been steadily decreasing since 2015.
Retention Rates for Chemistry and Pre-Chemistry Majors, 2015-2019 (OIA data)

Retention Rates for Chemistry and Pre-Chemistry Majors, 2015-2019, Hispanic Students Only (OIA data)

Retention Rates for Chemistry and Pre-Chemistry Majors, 2015-2019, Female Students Only (OIA data)
Retention Rates for Chemistry and Pre-Chemistry Majors, 2015-2019, Male Students Only (OIA data)

Fall Enrollment by demographic for Chemistry and Pre-Chemistry Majors, 2016-2020

Official Enrollment by Major
UNM Main Campus, 2016-2020

Fall

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<td>2020</td>
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Spring Enrollment for Chemistry and Pre-Chemistry Majors, 2016-2020

Official Enrollment by Major
UNM Main Campus, 2016-2020

Spring

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<tr>
<td>Year</td>
<td>All students</td>
<td>Hispanic Only</td>
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Spring Enrollment by demographic for Chemistry and Pre-Chemistry Majors, 2016-2020

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Time to Degree for Chemistry compared to other A&S Majors

Time to Degree by Major or College for Graduates in 2018-2019 (in years)

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<th>Chicana and Chicano Studies 3.0</th>
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<th>Speech &amp; Hearing Sciences 4.6</th>
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</table>
CCB majors are a diverse mixture of ethnicities mirroring the ethnic composition of the state. The principal minority student groups as of Spring 2020 are Hispanic (29%), American Indian (5%) and Asian (9%), with no African-American students. As of Spring 2020 the composition is exactly 50% male and 50% female but in the recent past women were a slight majority (~55-60%) of chemistry majors.

CCB did not traditionally make systematic efforts to recruit undergraduate students, relying instead on the perceived market value of the chemistry degree and its utility in preparing students for graduate and professional schools. The orientation sessions and open house described earlier are a step in the right direction. For several years, all formal undergraduate advising was handled by a single staff member, who also handled aspects of graduate student advising and record keeping. This system was changed when the College of Arts and Sciences hired an undergraduate advisor to focus on Chemistry, but that advisor ultimately reported to A&S. Several different advisors have held this position since its creation. Currently two advisors, who report to A&S, share responsibility for advising all Chemistry and Biochemistry majors. All advisors have participated in CCB orientation sessions throughout the years and maintained good relationships with the Undergraduate Advisory Committee regardless of personnel changes. A plan to recruit faculty to act as career advisors for junior and senior chemistry majors starting Fall 2013 never came to fruition, but students often approach individual faculty and ask for their advice informally.

CCB has also not traditionally kept consistent records of student placement, which has hampered our ability to contact departmental alumni. The Undergraduate Advisory Committee began to administer online exit interviews to the graduating seniors starting in May 2013 and continued to do this every year except for 2020. While this data was primarily used for program assessment reports, students had the option to include an email address so that CCB could contact them in the future. There has been no systematic effort to contact young alumni and involve them with CCB events.

**Graduate students**

*Master of Science degrees awarded by CCB*

<table>
<thead>
<tr>
<th>Year</th>
<th>MS Degrees Awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-2016</td>
<td>1</td>
</tr>
<tr>
<td>2016-2017</td>
<td>1</td>
</tr>
<tr>
<td>2017-2018</td>
<td>4</td>
</tr>
<tr>
<td>2018-2019</td>
<td>2</td>
</tr>
<tr>
<td>2019-2020</td>
<td>5</td>
</tr>
</tbody>
</table>
In contrast to the increasing undergraduate enrollments, the CCB graduate education program has been shrinking since 2006, reaching its smallest size in a decade as defined by numbers of students enrolled (45 in Fall 2011) or by student credit hours taught (453 in AY 2011-2012).

The trend in degrees awarded since 2015 is not clear, and this is perhaps due to the more stochastic nature of this metric, but the data indicate a significant reduction over the last 5 years.

In 2011-2012, CCB awarded 8 PhD and 3 MS degrees. As recently as Fall 2007, the department had >60 graduate students, and in 2005 we had over 80 graduate students. The number of degrees awarded in CCB in the last 5 years tracks with decrease in the number of graduate students in our program, as expected. In AY 2010-2011, CCB ranked second in A&S in number of PhD degrees awarded. CCB was behind History but ahead of all other natural sciences. It is not clear if the current decline in PhDs awarded will continue over the next 5-10 years. CCB has lost an unsustainable 9 tenure track faculty in the last couple years, with six of
these faculty being tenured. Only 3 of these faculty were lost to retirement. This could explain the remarkable decrease in PhD degrees awarded since 2017-18. New faculty hires have not replaced these faculty losses completely (≈50%). Since it takes at least 4 years for new faculty to produce PhD graduates, the current trend is likely to be in place for a number of years.

The department has traditionally admitted a large number of international students, principally from the People’s Republic of China (PRC). Over the last decade, the percentage of international students has averaged ~60%. In recent years, the fraction of domestic students has dropped from above 40% to below 40%, the fraction of domestic minority students has dropped below 10%, and the fraction of PRC students has declined. More students from the African continent and from Nepal make up our current international student population.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>OFFERS</th>
<th>ENTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-2015</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>2015-2016</td>
<td>32</td>
<td>17</td>
</tr>
<tr>
<td>2016-2017</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>2017-2018</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>2018-2019</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>2019-2020</td>
<td>24</td>
<td>12</td>
</tr>
</tbody>
</table>

Number of graduate applicants accepted and arriving at UNM between 2014 and 2020.

Recent trends in graduate student recruitment appear problematic (Fig. 8). Since 2014-2015, the number of offers has dropped by about 50%, however, these numbers are closely related to the number of tenure track faculty.

To increase the quality and quantity of the graduate student applications going forward, we would like to:

1. Raise CCB stipends, CCB TA stipends are ~$2000 annually lower than other flagship universities.
2. Increase faculty size, the overall decrease in faculty size reduces the number of prospective advisers for new students and the number of RA positions available.
3. Recruit international and domestic students, in the past we had relied on Chinese graduate students at a time when the economy of the PRC has been thriving complicates recruiting.
4. Reinvigorate the graduate education program to excite and attract students.

This last possibility has led to several proposals to re-organize the graduate program. Historically, serious disagreements within the faculty have prevented any consensus on the best path forward. However, in 2020, the efforts to reorganize the graduate program have been re-initiated.
**4D: Advisement Practices** Discuss the unit’s advisement process for students, including an explanation of how the unit has attempted to improve or address issues regarding its advising practices and to ensure inclusiveness and equity in advising.

**College advisors.** The College of Arts & Sciences provides advisement in various delivery options: group workshops, prescheduled one-on-one appointments, and walk-in visits. The philosophy of the advisors relies on the belief that the student/advisor relationship is defined by the student — this includes frequency of visits (we recommend once a semester) and topics discussed in the sessions. One-on-one visits are optional but encouraged.

The academic advisors can help students:
1. Make a plan for their undergraduate education and beyond
2. Figure out which classes to take next
3. Balance the different requirements of a UNM degree so they can graduate on-time
4. Understand the purpose of their degree and how it will fit into their overall career goals
5. Connect with on-campus resources to discover, explore, and land their dream career
6. With guidance when they are unsure of their next step

**One-on-one appointments.** All advisors offer appointment times strategically throughout the week. These are typically 30 minutes in length but, on occasion, we may suggest a full hour appointment. Some topics, such as initial transfer student appointments (scheduled in the months prior to your first semester), initial probation appointments, and returning from suspension appointments require two 30 minute slots.

A&S prefers in-person interactions but realizes that some students do not have the ability to come to campus for their visit. Students that are out of state, students that are studying abroad, or entirely online students are encouraged to call the front desk to schedule a phone or skype appointment.

**Walk-in visits.** The Advisors of A&S hold specific times during the week that students can be seen on a first come first serve basis. Walk in sessions serve the students with either quick questions or with an acute need. They can be limited in time and scope; if the issue isn't something that can be resolved during the walk–in, then the student will be assisted in scheduling the right kind of follow up visit.

**Group workshops.** The College requires visits at critical transition points in a student’s academic career. Each visit is intended to ensure that the students are equipped with specific information to be able to move forward while getting the most out of your college experience. Our advisement model embraces the Advising as Teaching and Learning Philosophy. In that spirit, specialized workshops have been designed that cover the benchmarks of every stage of the student’s academic career.

**4E: Student Support Services** Discuss any student support services that are maintained by the unit and evaluate the relevance and impact of these services on students’ academic success.

Many of our students require advisement directly from faculty members. While we do not have a formal approach for this, the department chair works closely with the A&S advisors to ensure the students get the information they need. Namely, the chair meets with the college advisors at least once per semester to communicate important information.

The website directs students as described below for research opportunities.
Students are encouraged to speak with faculty members regarding possible career paths in the chemical sciences. This includes, but is not limited to,

- Consultation regarding course requirements for majors and concentration
- Research opportunities
- Career directions

The following faculty advisors represent the main areas of specialization in Chemistry:

- Alisha Ray, adray@unm.edu (Allied Health Sciences, Chemistry For Non-Majors)
- Lisa Whalen, lwhalen@unm.edu (Organic Chemistry)
- John Grey, jkgrey@unm.edu (Physical and Analytical Chemistry, Electronic and Solar Energy Materials)
- Terefe Habteyes, habteyes@unm.edu (Chemical Physics, Analytical Chemistry, Photonics)
- Mark Walker, markcwalker@unm.edu (Chemical Biology and Biochemistry)

**4F: Graduate Success** Discuss the success of graduates of the program by addressing the following questions:

- How does the unit measure the success of graduates (i.e. employment, community engagement, graduate studies, etc.)?
- What are the results of these measures?
- Discuss the equity of student support and success across demographic categories.

In the past, the department has not tracked our undergraduate or graduate students following graduation. We are in the process of initiating multiple approaches to stay in communication with our graduates at all levels. Here are a couple examples.

1. For the past two semesters, the department has prepared a newsletter to be distributed via the UNM Foundation email list. Unfortunately, the department does not have direct access to this list, so we have worked with the UNM Foundation. The department chair was has initiated direct one-on-one communicate with numerous alumni in the past year which was a direct result of the newsletter. (Appendix J)

2. CCB is planning to initiate an exit survey to assess the students' perceptions of the quality of its undergraduate and graduate student learning and program effectiveness. The survey will include questions on students' satisfaction in four categories (achievement, experience, campus social climate, career). This survey will be administered every year to graduating students who have earned their BS, BA, MS, or PhD.

3. CCB is developing a departmental alumni contact database. We will use this database to stay in communication with our students to improve our community and also track the success of our graduates.
**Criterion 5. Faculty**

The faculty (i.e., continuing, temporary, and affiliated) should have appropriate qualifications and credentials and be suitable to cover the curricular requirements of each degree/certificate program.

**5A: Composition** After completing the Faculty Credentials Template (Appendix K), discuss the composition of the faculty and their credentials (i.e. proportion of senior versus junior faculty, proportion of women and underrepresented faculty, etc.).

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Research Area</th>
<th>PhD/Year</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeremy Edwards</td>
<td>Professor, Department Chair</td>
<td>Bioinformatics, Pharmaceutical Chemistry</td>
<td>University of California, San Diego - 1999</td>
<td></td>
</tr>
<tr>
<td>Atlas, Susan R.</td>
<td>Associate Professor</td>
<td>Physical Chemistry, Theoretical and Computational Chemistry</td>
<td>Harvard University - 1988</td>
<td></td>
</tr>
<tr>
<td>Cabaniss, Stephen E.</td>
<td>Professor</td>
<td>Analytical Chemistry, Chemical Education, Environmental Chemistry</td>
<td>University of North Carolina - 1986</td>
<td></td>
</tr>
<tr>
<td>Chen, Changdong</td>
<td>Assistant Professor</td>
<td>Electronic Materials</td>
<td>Georgia Institute of Technology - 2017</td>
<td></td>
</tr>
<tr>
<td>Depperman, Ezra C.</td>
<td>Lecturer III</td>
<td></td>
<td>University of New Mexico - 2006</td>
<td></td>
</tr>
<tr>
<td>Evans, Deborah G.</td>
<td>Professor</td>
<td>Physical Chemistry, Theoretical and Computational Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fulghum, Julia E.</td>
<td>Professor</td>
<td>Chemical Biology and Biochemistry</td>
<td>University of North Carolina - 1987</td>
<td></td>
</tr>
<tr>
<td>Gold, Brian A.</td>
<td>Assistant Professor</td>
<td>Chemical Biology and Biochemistry, Organic Chemistry, Pharmaceutical Chemistry, Theoretical and Computational Chemistry</td>
<td>University of Wisconsin - 2017</td>
<td></td>
</tr>
<tr>
<td>Grey, John K.</td>
<td>Associate Professor</td>
<td>Electronic and Photonic Materials, Physical Chemistry</td>
<td>McGill University - 2004</td>
<td></td>
</tr>
<tr>
<td>Guo, Hua</td>
<td>Distinguished Professor</td>
<td>Theoretical and Computational Chemistry</td>
<td>School of Chemistry and Molecular Sciences</td>
<td></td>
</tr>
</tbody>
</table>
**5B: Course-Load** Explain the process that determines and assigns faculty course-load (i.e., how many courses do faculty teach per semester, how does the unit determine faculty assignment to lower division vs. upper division courses, etc.). Describe the faculty-to-student and faculty-to-course ratio, and any impacts this has on unit success.

The standard course load for Arts and Sciences faculty is two courses per semester. In Chemistry, we have a course load of one per semester for our research active faculty. All Chemistry tenured and tenure track faculty are classified as ‘research active,’ and the department does not have a metric for defining research
active faculty. Each faculty is expected to teach one undergraduate course and one graduate level or elective course. This pattern is normally followed; however, there are a few cases where faculty have taught two undergraduate course per year. The teaching load is monitored by the department chair, in consultation with the associate chair for undergraduate studies, to ensure all undergraduate courses are covered prior to opening graduate courses.

The CCB department has 7 full time lecturers. However, some of these lecturers have commitments to other entities on campus, e.g., the BA/MD program. The lecturers are expected to teach three courses per semester as a full load. The lecturers cover most of the 100 and 200 level courses, with the tenure track faculty primarily covering the 300 and 400 level courses.

5C: Professional Development Describe the professional development activities for faculty within the unit, including how these activities are used to sustain research-related agendas, quality teaching, and students’ academic/professional development at the undergraduate and graduate level. Describe what measures the department takes to ensure appropriate support, mentoring, workload and outcomes for faculty of color and members of groups that are traditionally under-represented in your field.

Faculty professional development. The department currently assigns a mentoring team to each junior faculty member in the department. The mentoring team is responsible for helping the junior faculty member develop into an outstanding researcher and educator. For example, the mentoring committee often helps identify funding mechanisms for the junior faculty member and review draft proposals and manuscripts. Additionally, the mentoring team helps the junior faculty member integrate departmental, university-wide, and community service into their careers. The junior faculty member is expected to meet with the mentoring team at least monthly, although the interactions are often much more frequent.
Criterion 6. Research, Scholarship, & Service

The unit should have structures in place to promote active engagement in research, scholarly, and creative works among the faculty and students (if applicable, differentiate for each undergraduate and graduate degree and certificate program).

6A: Scholarly & Creative Works Describe the scholarly/creative works and accomplishments of the faculty. Explain how these support the quality of the unit; what are particular areas of strength?

Faculty research in the UNM Department of Chemistry and Chemical Biology spans a broad range of disciplines and cutting-edge topics of great societal importance. Faculty investigators have diverse backgrounds that often merge with those outside the traditional boundaries of Chemistry. Research in the Department is categorized in terms of the following three thrusts:

1. **Chemical Biology:** Faculty in this area cover a wide range of sub-specialties and have ongoing or potential collaborative relationships with several other units on campus, including Biology, the Center for Biomedical Engineering, the College of Pharmacy and the School of Medicine. Topics include, but are not limited to, drug discovery, biological molecule structure-function relationships, medicinal chemistry, and imaging. Faculty in this area typically collaborate with UNM School of Medicine as well as the Center for Biomedical Engineering. The divisions of Biological and Medicinal Chemistry are the 4th and 2nd largest in the ACS as of 2012, and the potential for student recruiting and placement is high.

2. **Catalysis:** Catalysis research bridges the traditional areas of organic and inorganic synthesis and mechanism, enzyme chemistry and theory. Catalysis is a particular interest of the UNM Chemical Engineering department and of the Advanced Materials Laboratory group, which are comprised of both UNM faculty and national laboratory staff. Adding this focus area to the department’s plan recognizes the strength of several research efforts already present in the department and should facilitate further collaboration as the program strives for greater national and international recognition. Research in catalysis spans both biological and industrial applications and further benefits from synergized experimental and theoretical approaches.

3. **Electronic and Photonic Materials:** Molecular-based materials have enormous potential to transform traditional electronics and chemists are poised to make large contributions to this global effort. Specifically, the harvesting, storing and productive use of solar energy requires improvements in understanding electronic materials and their behaviors; other energy-related technologies should also benefit from fundamental work in this area. At UNM, we enjoy the close proximity of Department of Energy National Laboratories (Sandia and Los Alamos National Labs) as well as materials-oriented centers, which enables many potential collaborations. The department also has many cutting-edge facilities for energy materials research, which provide students with hands-on exposure to current state-of-the-art applications.

The CCB department maintains a high level of research activity despite the low number of research active faculty. We currently have 15 research active faculty within the department. CCB faculty are engaged in highly significant research projects, as evidenced by the citation rates to departmental faculty. The number of citations to department faculty has been steadily growing over the last 6 years, as is illustrated below. For example, in 2014, there were an average 264 citations to the work from departmental faculty members, while in 2020, the average number of citations grew to 392.
Total citations to publications authored by CCB.

Citations from 2014-2020 to CCB faculty publications. The chart is ordered by rank and number of citations within the rank. Distinguished Professors (Guo, Kirk), Professors (Edwards, Grey, Cabaniss, Rack, Fulgham, Garver, Evans (does not maintain a Google Scholar page)), Associate Professors (Habteyes, Atlas, Keller (does not maintain a Google Scholar page)), Assistant Professors by hire date (Walker, He, Gold, Chen), and new Assistant professor arriving in Fall 2021 (Elenewski).

Citations to affiliated CCB faculty.
Table of citation data for CCB faculty.

6B: Research Expenditures If applicable, include a summary of the unit’s research related expenditures, including international, national, local, and private grants/funding. How is faculty-generated revenue utilized to support the goals of the unit?

CCB research expenditures have steadily increased over the past 5 years. There was a dip in 2019 due to a few grants expiring. However, we anticipate that 2019 will be an outlier and the trend will continue to grow in 2021.
6C: Research Involvement  
Give an overview of the unit’s involvement with any research labs, organizations, institutes, or other such centers for scholarly/creative endeavors (i.e. formal partnerships with Sandia Labs, CHTM, community organizations, local media, etc.).

CCB researchers have active relationships and collaborations with researchers at Sandia National Laboratories (SNL), Los Alamos National Laboratory (LANL), Air Force Research Laboratory (AFRL), and UNM’s Center for High Technology Materials (CHTM). Profs. Kirk and Habteyes are associate faculty at CHTM and maintain all or part of their laboratories at CHTM. Both Kirk and Habteyes are also on the CHTM Advisory Board. Research involvement extends to include recruitment of our students at SNL, LANL, and AFRL.

6D: Student Opportunities  
Describe the opportunities for undergraduate and graduate students to be involved in research/creative works through curricular and extracurricular activities.

Undergraduate Research  
For many years (including the full period for this review), the Chemistry department has maintained an active program of opportunities for undergrads to participate in research. An overview of research opportunities for undergrads is provided at [http://chemistry.unm.edu/student-info/undergraduate/research.html](http://chemistry.unm.edu/student-info/undergraduate/research.html). Every research-active faculty member is encouraged to take on undergrads as researchers in their groups. Course credit for undergrad research is available through CHEM 495/496 (Undergraduate Problems), and CHEM 497/498 (Senior Honors Research). No exact count has been taken, but the faculty estimate that over the past year approximately 10 undergrads were involved in undergraduate research, and 8 publications include undergraduates as authors.

A quite large number of scholarships and other funding opportunities exist to support undergrad research. These include:
Stephen F. Martin and Fay Evans-Martin Endowment for Undergraduate Research in Chemistry
Ann Kahn Memorial Prize in Chemistry
Charles Leroy Gibson Scholarship
Maurice L Hughes Scholarship
Mike Millican Prize in Chemistry
Paul Mozley Award
J.L. Riebsomer Memorial Endowment
Joan Willard Hemsing Tinoco Scholarship
Dean E. Uhl Merit Scholarship in Chemistry
Dr. Thomas Whaley Endowed Memorial Scholarship

The Martin Scholarship and the Whaley Scholarship are especially worth noting, as both provide stipends and research supplies for summer undergrad research to several chemistry majors each year. During the Fall and Spring semesters, the work-study program also provides work-study-eligible students with funding for undergrad research.

Graduate Research

The Masters and PhD degrees in Chemistry are research degrees. Each graduate student must join a research group and must actively participate in research and publication in order to complete their degree. All graduate students are supported financially either as Research Assistants (RAs, funded by external grants and awards) or as Teaching Assistants (TAs, funded by the department). RAs are able to pursue research toward their degree full-time; TAs have teaching duties in addition to their research efforts. Equipment, facilities, research chemicals and supplies, etc., are supplied by the research advisor, almost exclusively from externally awarded funding. The graduate program, including numbers of grad students over the report period and overall research activity, is described in more detail in Section 4 of this report.

6E: Community Service Describe faculty members’ service to the UNM community and beyond (local, national, global). Examples include community engagement practices, volunteering on committees, professional organization membership/leadership, etc.

CCB faculty contribute significantly to the UNM community and to the larger national and international scientific community.
<table>
<thead>
<tr>
<th>Name</th>
<th>UNM Service</th>
<th>Outside UNM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeremy Edwards</td>
<td>UNM Cancer Center Leadership Team, UNM Curriculum committee, CARC Advisory</td>
<td>NCI Study Section Member 2020-2024, NCI Study Section Member 2015-2019, Editorial Board ISRN Biomathematics (2011-present), J. of Molecular Microbiology and Biotechnology (2001 – present), Grant reviewer for NIH and DOE</td>
</tr>
<tr>
<td></td>
<td>Board Member, UNM Chemical and Lab Safety Committee</td>
<td></td>
</tr>
<tr>
<td>Atlas, Susan R.</td>
<td>Faculty Advisory Committee</td>
<td></td>
</tr>
<tr>
<td>Cabaniss, Stephen E.</td>
<td>Chair of the website redesign committee, UNM large equipment committee, CCB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building Renovation Chair</td>
<td></td>
</tr>
<tr>
<td>Chen, Changdong</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depperman, Ezra C.</td>
<td>Faculty Senate, PI Web Based Course Facilitator Grant, Web design committee</td>
<td></td>
</tr>
<tr>
<td>Evans, Deborah G.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fulghum, Julia E.</td>
<td>Associate Dean, PI for the UNM ADVANCE Program</td>
<td></td>
</tr>
<tr>
<td>Gold, Brian A.</td>
<td>Graduate Studies Committee</td>
<td></td>
</tr>
<tr>
<td>Grey, John K.</td>
<td>Faculty Search Committee chair, Departmental Advisor, Women's Student</td>
<td>Grant reviewer for National Science Foundation, ACS-PRF, Department of Energy</td>
</tr>
<tr>
<td></td>
<td>Veterans of UNM, Research Allocations Committee</td>
<td></td>
</tr>
<tr>
<td>Guo, Hua</td>
<td>Faculty Awards committee, UNM-AFRL liaison committee, Member of Internal</td>
<td>Member of Board Chinese American Professor Association (CAPA), Editorial board for J. Theo. Comput. Chem. Theo. Chem. Acc., Senior Editor for J. Phys. Chem., Vice Chair: Gordon Research Conference on Molecular Interaction and Dynamics, Grant reviewer for DOE, NSF, PRF, DOD</td>
</tr>
<tr>
<td></td>
<td>Advisory Board CARC</td>
<td></td>
</tr>
<tr>
<td>Habel-Rodriguez, Diana</td>
<td>Faculty Advisory Committee, Graduate Studies Committee, PI Web Based Course</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Facilitator Grant</td>
<td></td>
</tr>
<tr>
<td>Habteyes, Terefe</td>
<td>Search Committee Member</td>
<td></td>
</tr>
<tr>
<td>He, Yi</td>
<td>The Graduate Studies and Recruiting Committee</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Position/Committee/Role</td>
<td>Additional Information</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ho, Jo</td>
<td>Associate Chair for Undergraduate Studies, Member of Faculty Award Committee, Member of Faculty Senate Admission and</td>
<td>Member of Governing Council of Albuquerque Institute of Math and Science @ UNM, attending monthly meeting and graduation ceremony</td>
</tr>
<tr>
<td></td>
<td>Registration Committee, K-12 coordinator, Assessment Coordinator, Teaching Assistant Coordinator, Coordinator of general chemistry teaching, Member of Faculty Senate Curriculum Committee, Member of Faculty Senate Admission and Registration Committee, Faculty Advisor for “Medical Spanish and French Society”, Guest Trainer to Chemistry Tutors at CAPS, 2018</td>
<td></td>
</tr>
<tr>
<td>Keller, David J.</td>
<td>Undergraduate Committee</td>
<td></td>
</tr>
<tr>
<td>Kirk, Martin L.</td>
<td>Faculty Advisory Committee, Associate Chair for Graduate Studies, UNM Generator Task Force Committee,</td>
<td>Advisory Board Member New Mexico Institute of Mining and Technology, Advisory Board Member Center for High Technology Materials, International Organizing Committee - Molybdenum and Tungsten Enzymes Conference, MOTEC, Local NM Section of the American Chemical Society</td>
</tr>
<tr>
<td>Knottenbelt, Sushilla Z.</td>
<td>Undergraduate Committee BA/MD Committee on Curriculum and Student Progress, Director of A &amp; S BA/MD program, Co-facilitate the Learning Studio Community of Practice to provide information and a means of sharing expertise to instructors and others interested in teaching in collaborative learning classrooms, Member of Learning Environments Subcommittee on Learning Studios, Member of the Teaching Enhancement Committee, Member of School of Medicine (SOM) Curriculum Committee (CC), Member of search committee to hire two new Biochemistry Lecturers, Education mentor of Dr. Tehrani (Assistant Professor of Psychiatry), Faculty mentor of Dr. Hayek, Lecturer III, Department of Biochemistry.</td>
<td></td>
</tr>
<tr>
<td>Rack, Jeffrey</td>
<td>UNM A&amp;S Tenure and Promotion Committee</td>
<td>Secretary, ACS Division of Inorganic Chemistry, Vice President, Inter-American Photochemical Society</td>
</tr>
<tr>
<td>Ray, Alisha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walker, Mark C.</td>
<td>Faculty Advisory Committee, Graduate Studies Committee, Webdesign committee</td>
<td>Early career NIH study section member.</td>
</tr>
</tbody>
</table>
| Whalen, Lisa J. | Undergraduate Advisory Committee, Faculty advisor  
|                | Lobo Chemistry Club, BA/MD  
|                | Committee on Curriculum and Student Progress, BA/MD  
|                | Basic Sciences Working Group |


**Criterion 7. Peer Comparisons**

The degree/certificate program(s) within the unit should be of sufficient quality compared to relevant peers. (If applicable, differentiate for each undergraduate and graduate degree and certificate program offered by the unit.)

**7A: Analysis** Choose 3 peer departments from the Peer Comparison Template (Appendix L) to contrast with the unit. After completing the Template for these departments, provide an analysis of the comparison.

Please describe aspects of your program that are unique compared to these peers.

§ The unit may choose to select an alternative peer institution designated by a relevant regional, national, and/or professional agency.

We have defined a set of 23 peer institutions (See table below). The chemistry departments at these universities range from highly regarded “top 20” programs to much smaller departments that do not offer a Ph.D.

**Peer Institutions**

- Arizona State University
- Florida International University
- New Mexico State University-Main Campus
- Oklahoma State University-Main Campus
- Texas A & M University-College Station
- Texas Tech University
- The University of Tennessee
- The University of Texas at Arlington
- The University of Texas at Austin
- The University of Texas at El Paso
- University of Arizona
- University of California-Riverside
- University of Colorado-Boulder
- University of Colorado Denver
- University of Houston
- University of Iowa
- University of Kansas
- University of Missouri-Columbia
- University of Nebraska-Lincoln
- University of Nevada-Las Vegas
- University of Oklahoma-Norman Campus
- University of Utah

UNM’s Chemistry graduate program is ranked 15th out of these 23 chemistry departments based on US News and World Reports rankings.

However, the Chemistry department at UNM has only 21.5 permanent faculty members, which includes only 15 tenure-track faculty and 6.5 lecturers (with one new assistant professor arriving Fall of 2021 and one professor on unpaid leave and unlikely to return). The CCB faculty size is near the bottom when compared to this group. The current CCB faculty size is much smaller than chemistry faculties at the other “flagship” institutions (see figure in the summary section). While ranking departments by size may be
relatively unambiguous, size alone does not ensure high quality research and education. The US News and World Report ranking is based on surveys that reflect reputation in the field. The other rankings were all compiled by the National Research Council (NRC) based on a set of 21 metrics. S-rankings emphasize those metrics which scholars in the field consider most important, while research rankings use subsets of the metrics related to research productivity. The range between high and low for a particular ranking can be thought of as a confidence interval. UNM CCB department is thus seen as significantly weaker than the departments at other flagship universities in the Four Corners states and Texas, although stronger than departments at NMSU and Texas Tech.

The NRC also ranks departments according to diversity and student-valued metrics, and in these areas, UNM typically is among the top 2-4 schools listed.

These various rankings suggest that while CCB may have a relatively good environment for students, UNM lags behind other flagships in the region with respect to the quality and ‘profile’ of its chemistry department. This is probably related to CCB’s small faculty size relative to those departments.
Criterion 8. Resources & Planning

The unit should demonstrate effective use of resources and institutional support to carry out its mission and achieve its goals.

8A: Budget Provide an analysis of the unit’s budget, including support received from the institution and external funding sources.

§ Include a discussion of how alternative avenues (i.e., summer bridge programs, course fees, differential tuition, etc.) have been explored to generate additional revenue to maintain the quality of the unit’s degree/certificate program(s) and courses.

In recent years, resource allocation and planning has been performed principally by the department Chair, Accountant, and Department Administrator on a year-to-year basis. Working directly with the College Financial Officer, the Accountant reconciles all expenses and ensures that budgets are funded. The department Chair has enlisted a Faculty Advisory Board (4 faculty that are elected every other year with a two-year term) to discuss and approve of any large expenditures, especially those impacting the faculty as a whole.

Since the last APR the department has gone through two reorganizations in the Administrative area. Although the department has always had an Accountant, the work in the accounting office was split between hard and soft funding. However, after two years of this model, the department has gone to having the Accountant oversee a Fiscal Service Tech, who does all the purchasing for the department. Purchasing for the department is a sizable effort because of the large amount of chemical replenishment. With one staff ordering all supplies, the department is able to better negotiate the best prices for faculty/PIs. The Accountant oversees all finance activities for the department including salaries, operating budgets, grants and contracts spending, and cost centers.

The department has five principal revenue sources.

1. “Hard money” support from the university comes from tuition, and state formula revenue is used for instructional, administrative and general expenditures (I&G). In FY20, the department received $3,759,887 in I&G funds to cover faculty and staff salaries, TA’s, and operating expenses.

2. “Soft money” support is derived from funded grant overhead (F&A, for facilities and administration expenses) and has been used principally to support research efforts and start-up packages for new faculty.

   · From FY14 to FY18 the total F&A generated by the department increased steadily from $606K to $870K and the F&A returned to the department was 14% from the funds generated, respectively between $85K and $121K. In FY19 the total F&A generated was drastically reduced to $481K with only $34K in return. FY20 saw a $512K in generated F&A and a $33K returned to the department.

   · The reduced F&A generated in FY19 was caused by losing 4 faculty in the department, along with their grants. During FY20 the department hired new faculty and the number of grants increased, but the total F&A generated has not caught up yet with the old values.

   · The reduction in F&A returned to the department is only partially explained by the reduction in total F&A generated. The other reason was the halving of the amount returned to the department by the College when the percentage returned was changed from 40% to 20% of the F&A returned.
to College by the OVPR office. The amount of F&A received by the department was reduced from 14% to 7% of the total generated F&A.

- The dramatic reduction of the F&A returned made it difficult for the department to fund startup packages and research expenditures. To compensate, the department has allocated funds from operating expenses, further impacting the department’s finances.

3. **Endowment funds** are derived from a variety of accounts overseen by the UNM Foundation, mostly donations for specific scholarships. The department must follow the donor’s criteria in distributing funds. The department is relying on endowments to support both undergraduate and graduate students to the best of its ability. The department is actively looking for new donors to increase the amount of endowed funds in order to benefit the students.

4. **Course fees** are a substantial source of revenue that comes from student fees charged for labs. The amount of course fee collected has increased steadily in the previous years, reaching $250K in FY20. The department uses these funds to support expenses directly related to student success in the classroom, which includes replacements of large equipment, glassware, printers/scanners, workbooks, etc. At the end of the fiscal year, the Accountant has to reconcile the account and submit to the Provost a report on how the money was used.

5. **Services Center**

- **Mass Spectrometry Facility** processes and charges samples for UNM and outside clients. The College has provided the funds to cover the losses accumulated before 2010. The revenue was modest in the previous years but a new $323K mass spectrometer was purchased with NSF funds plus cost share funds from different UNM departments, including the CCB department. The new equipment was installed in October 2020 after many COVID related delays and has generated $3.5K in revenues since then. We are looking forward to future revenues from this investment.

- **Nuclear Magnetic Resonance Facility (NMR)** has been part of the Chemistry Department for many years and used by the researchers in both the Department and other departments, including outside clients. Unfortunately, the equipment is old and the need for repairs is draining funds from the department above the revenues created. The revenues are based on the numbers of users and have dropped significantly in FY18 and FY19 when we lost faculty. Finding new clients has proved difficult. The Department has established a 5-year payment plant to cover the $27K deficit after closing FY20.

**8B: Staff** Discuss the unit staff and their responsibilities (including titles and FTE). Include an overall analysis of the adequacy and effectiveness of the staff composition in supporting the mission and vision of the unit.

The 12.5 full-time CCB staff positions can be divided into office staff and technical staff, with the latter group being subdivided into teaching and research groups.

The departmental administrator (DA) is the departmental office manager, chief fiscal agent and chief human resources agent, and requires a highly responsible individual with a variety of skills and expertise. Felicia Rider is our current DA of 7 years and she has a Master’s in Public Administration and SHRM-CP certification in Human Resources. All other office staff report to the DA, including a departmental
accountant, a fiscal technician, an advisement coordinator, a receptionist/administrative assistant and a building manager. This group is often assisted by one or more student employees.

The department facilities and instrumentation director, Dr. Karen Ann Smith, is charged with managing CCB shared instrumentation and supervising one instrumental technician (Sr. Research Scientist), one electronic/computer technician (Research Engineer), and the Chemical Safety Officer. Shared instrumentation includes 3 NMR instruments and the mass spectrometry facility, as described in section VIII.B below. Dr. Smith has also been the Building Renovation “Champion.” She has been instrumental in ensuring two large renovations projects have had department strategic design input and feedback to the architect and contractors.

The CCB director of undergraduate education, Principal Lecturer Dr. K. Joseph Ho, oversees the general chemistry teaching laboratory staff, and Principal Lecturer Lisa Whalen oversees the organic chemistry laboratory staff. Three teaching lab technicians report to the supervising lab technician, Gary Bush. Currently, Kali Levison and Sarah Matte support the general chemistry labs taught in the SMLC, Sharon Boyd supports the organic labs taught in SMLC with a part-time tech, Russell Milazzo. Gary Bush currently supports the analytical and physical laboratory sections because the department has a vacancy for another full-time lab technician 0.5 FTE are needed to support all undergraduate laboratories and the department is currently down 1.5 FTE because of reduced funding from New Mexico State. The hope is these positions will be filled once the Covid-19 crisis is over.

The UNM library system provides direct access to numerous electronic and print journals, databases and other information resources relevant to chemical teaching and research (see http://libguides.unm.edu/chemistry). CCB has a designated librarian, Donna Cromer, who assists with student training and chemical acquisitions. Students and faculty have electronic access to all ACS, Elsevier, Pergamon and other journals, and to the Web of Science and SciFinder Scholar search services. Data librarians are also available to assist with NSF- and NIH-mandated data plans.

8C: Advisory Board If the unit has an advisory board, describe the membership, their charge, and discuss how the board’s recommendations are incorporated into decision-making.

Following the last APR, Department Chair Steve Cabaniss created an external advisory board (EAB) consisting of people who knew the department and could add valuable input. Their first meeting was in January 2014. The EAB meets each Spring to review the status of the department. The External Advisory Board (EAB) provides the department of Chemistry and Chemical Biology (CCB) with advice, perspective and connections to departmental stakeholders. The board consists of 5-7 members appointed by the department chair after consultation with the faculty advisory committee. The board membership should include departmental alumni, chemical scientists from national labs and private companies in NM, and academic chemists from outside of NM. Members are expected to meet as a board at least once every two years and to be available for occasional consultation about departmental issues.

Principal expectations of the board include:
A. Advising the department chair and faculty on strategic directions in research, education and outreach
B. Evaluating overall departmental progress and accomplishment and in some cases the outcomes of specific policies and initiatives, and communicating these evaluations to the chair and to the Dean of Arts and Sciences
C. Representing the views of various external stakeholder groups, including departmental alumni, New Mexico chemical employers, the New Mexico public, and the national community of chemical educators.
Below is the list of members:

**Carlos Bustamante**
- Professor of Chemistry, Physics and Molecular and Cell Biology, Raymond and Beverly Sackler Professor in Biophysics at the University of California, Berkeley
- UNM Chemistry faculty 1982-1990, member National Academy of Sciences, Howard Hughes Medical Institute Investigator, American Physics Society Fellow

**David Chandler**
- Senior Scientist, Sandia National Lab.
- B.S. Chemistry from UNM 1975, Fellow of American Physical Society, Associate Editor of the *Journal of Chemical Physics*

**Yolanda King**
- TASC consultant, retired from Department of Defense after working with Air Force Research Lab and Defense Threat Reduction Agency.
- B.S. (1976) and Ph.D. (1981) in Chemistry from UNM, board member of New Mexico Network for Women in Science & Engineering,
- Fellow of American Institute of Aeronautics and Astronautics (AIAA)

**Stephen Martin**
- Currently the M. June and J. Virgil Waggoner Regents Chair in Chemistry at the University of Texas, Austin.
- B.S. Chemistry (1968) from UNM, *Advisory Board of Organic Synthesis*, department chair,
- Fellow of the American Association for Advancement of Science (AAAS)

**Peter Sherwood**
- Affiliate professor, University of Washington, Dean (emeritus) of Arts and Sciences at Oklahoma State University.
- Regents Professor of Physics Emeritus, Oklahoma State University and University Distinguished Professor of Chemistry Emeritus, Kansas State University Academic program review committee for CCB in 2013.
- Chair, Chemistry department at Kansas State University, Fellow of the Royal Society of Chemistry, Fellow of the Institute of Physics, Fellow of the American Vacuum Society

**Valerie Varoz**
- Chemistry teacher at Sandia High School in Albuquerque. B.S. Chemistry (2007) from UNM, National Board Certified Teacher, former science chair at SHS
**Criterion 9. Facilities**

The unit facilities should be adequately utilized to support student learning, as well as scholarly/research activities.

**9A: Current Space** Provide an updated listing from UNM’s current space management system of the spaces assigned to your unit (e.g., offices, conference rooms, classrooms, laboratories, computing facilities, research space, etc.). Discuss the unit’s ability to meet academic requirements with current facilities.

- Explain if the unit has any spaces that are not documented in UNM’s space management system.
- Explain the unit’s unmet facility needs.
- If applicable, describe the facility issues that were raised or noted in the last APR. What were the results, if any?

**Space.** The department of Chemistry and Chemical Biology is centered in Clark Hall, where the department offices are located, but occupies space in several other buildings as well. Clark Hall currently has ~10,000 ft² of office space (faculty offices + departmental offices), 14,000 ft² of instructional lab and support space, ~2000 ft² of shop and basement utility space, and 24,000 ft² of research lab space.

Clark is comprised of two wings; the older, 2-story Clark wing is ~60 years old, while the newer 3-story Riebsomer wing is ~40 years old. In 2016, phase I ($16M) of the Clark renovation was completed, and we are currently undergoing phase II (and likely final) renovations, with a price tag around $17M. Once these renovations are complete, we will have renovated all laboratory and office space within Clark Hall. The fully renovated Clark Hall can house ~15 average sized research groups. Therefore, for expansion to our desired size, additional research space will be needed (see below).

The Science and Math Learning Center currently houses all the general chemistry and organic teaching labs and has offices for lab personnel and TA office hours.

Several CCB faculty have their principal lab spaces outside of Clark Hall, however, following completion of phase II renovations, these research labs will move into Clark Hall. For example, Hua Guo’s theoretical and computational group is currently located in Bandelier East, and will move into the computational facility in the basement of Clark when phase II is complete. Terefe Habteyes has his principal lab at the Center for High Tech Materials (CHTM), which is located on South campus ~1 mile from Clark Hall, and he will move into two labs and synthetic space for phase II renovations are complete.

**Equipment.** CCB has equipment available in individual research group laboratories, through teaching facilities (when not being used for instruction) and via the Analytical Chemistry Service directed by Dr. Karen Ann Smith. The Analytical Chemistry Service facilities are equipped with modern, state-of-the art equipment and operated by well trained staff. The facilities include magnetic resonance, x-ray and mass spectrometry instruments to support investigators wishing to analyze compounds ranging from organic small molecules to large proteins.

The Nuclear Magnetic Resonance (NMR) Facility contains 3 spectrometers, all with temperature control, gradients, and multiple RF channels. It is housed in the basement of Clark Hall. The spectrometers are:

- Bruker Avance II 500 used primarily for liquids with 3 solution probes including a Prodigy cryoprobe
- Bruker Avance 300 widebore used primarily for solids with 8 solids probes and a 5mm solution probe
- Bruker Avance 300 standard bore for liquid only with 2 probes.

The CCB Mass Spec Facility is located in the basement of Clark Hall. It contains a Waters Xevo G2 XS Quadrupole Time-of-Flight (QToF) Mass Spectrometer. Samples may be introduced via an Acquity UPLC
H-Class Plus UltraPerformance Quaternary LC System, a Gas Chromatography System (APGC), and direct insertion solid probe (ASAP) and sample ionization probes (ESI and APCI). It has an extended mass range of up to m/z 100,000.

Appendix M lists equipment in individual and teaching labs.

With the exception of several compute-intensive research groups, the department does not maintain significant computing facilities besides workstations and groups of workstations. Two compute-intensive research groups host high-end (GPU-enabled, multicore) workstations and compute clusters in their labs, along with local disk arrays, high-end visualization equipment, and virtual-reality (VR) equipment. These capabilities are used for computer simulations, local code development, prototyping, smaller-scale calculations, and outreach purposes. These research groups and several other labs in the department also utilize other sources, including the UNM Center for Advanced Research Computing (CARC), for compute-intensive production applications.

9B: Future Space Needs Discuss any future space management planning efforts related to the teaching, scholarly, and research activities of the unit. Include an explanation of any proposals that will require new or renovated facilities and how they align with UNM’s strategic planning initiatives.

§ Explain the potential funding strategies and timelines for these facility goals.

It is clear that the space within Clark Hall is not sufficient to house a department of our desired size. Renovations are expensive, and it is more expensive to renovate space than it is to build new buildings. During the recent two phases of renovation, it was cost prohibitive to maintain research space in the Clark wing. Therefore, all the research space is contained within only the Riebsomer wing. The Riebsomer wing can house about 15 research groups. Currently, we have three computational groups (Guo, Yi, Atlas). We have available space (after the renovations) to bring in three new research groups. However, this is still insufficient, based on faculty size at our peer institutions. We estimate that we need 20 experimental research labs to financially support the infrastructure of a chemistry department (i.e. NMR facility, MS facility, etc). Therefore, it is essential that a new building for Chemistry is constructed within ~5 years.

Currently, we believe the only opportunity to obtain this new building is to partner with other science departments within A&S to obtain a new building that we have been unofficially calling the “molecular biosciences” building. Chemistry needs seven research labs within this new proposed building. Based on information from the UNM administration we anticipate this building to be constructed within 10 years, which is too slow to meet the growth needs of CCB. The Biology Department also has an urgent need for this new building, and there are ongoing discussions to see if it is possible to accelerate the timetable for this building.
Conclusion. Strategic Planning

Discuss the unit’s strategic planning efforts going forward to improve, strengthen, and/or sustain the quality of its degree programs (if applicable, differentiate between undergraduate and graduate). Address all criterion, including but not limited to: student learning outcomes, curriculum, assessment practices, recruitment, retention, graduation, success of students/faculty, research/scholarly activities, resource allocation, and facility improvement.

Faculty Hiring and Retention.
As is clear from this document, faculty retention is critical for the success of CCB. Since the new chairs term was initiated on 1/1/2020, CCB lost two more faculty, Qin and Le. On the surface, these departures seem to suggest continued problems, however, these two departures were unexpected circumstances. First, the Le departure was driven by the stress of the COVID pandemic. Secondly, the department of Qin was very surprising, and we put together a very strong retention package with the support of the Provost and the Dean. Additionally, the as a result of the Qin departure, we were able to provide ~5% preemptive raises to two CCB faculty. We are still surprised with the Qin departure, which was primarily driven by the desire for him to move to the East Coast.

It is too early to say our retention problems are behind us, but we do expect the rate of departure to significantly reduce. Part of what will reduce the departure rate, will be new hires to build the department to sufficient numbers. Additionally, there is a growing belief that a commitment diversity and a desire to be in NM should be an important aspect used in future searches.

Undergraduate Program.
The undergraduate program is strong and we are providing high quality chemical education to our students. Therefore, we are not proposing dramatic changes to this in the future. We currently have two primary focuses that will help us continue improving chemistry education.

1. Increase online education offerings. In spring 2021, we will offer the entire general chemistry sequence as an online MAX course. This includes the labs. We plan to continue growing the online courses within the department.

2. We are in the initial phase of discussions to redesign the undergraduate education committee. Currently we have a single committee the covers the entire undergraduate curriculum. However, most of the work of this committee deals with the general chemistry and organic chemistry courses. However, we really need to devote more time to the curriculum for chemistry BS and BA students. Therefore, we are discussing splitting the undergraduate committee into two separate committees.

Graduate Program.
The graduate program has struggled, and this is partially due to the low faculty numbers. The low faculty numbers lead to smaller incoming classes. In the past year, Martin Kirk has taken on the role of associate chair for graduate studies, and he, along with the others members (Walker, He, Gold, and Chen) have re-energized this committee. It is very unfortunate that due to COVID, we do not see the increasing graduate student enrollment we anticipated. However, we expect for the outstanding work of this committee to be readily apparent when the pandemic comes to an end.

Building Plans.
It is very important to secure new laboratory space for departmental growth. As discussed above, strategic planning to secure a new building is one of the most pressing issues for the department.
Appendices
# Handbook for Faculty Members of the Department of Chemistry and Chemical Biology

Approved April 3, 2013  
Amended February 2018

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I. Preface
This Handbook provides the faculty of the Department of Chemistry and Chemical Biology (CCB) with a written record of departmental procedures and policies. It has been constructed to be a continuation of University procedures and policies that are outlined in the UNM Faculty Handbook (http://handbook.unm.edu). The policies and procedures outlined herein are subject to revision as a result of careful consideration and 2/3 majority vote of the CCB faculty.

II. Authority
Article II, (College and Departmental Organization) in Section 4(a) of the Faculty Constitution (which appears as Policy A51 in the Faculty Handbook) states as follows:

Sec. 4(a) Departments: The Faculty of each Department shall, with the advice and consent of the Dean of the College, decide upon the organization and procedure for the efficient functioning of the Department.

The CCB bylaws and guidelines that follow amplify and complement parts of the UNM Faculty Handbook. Nothing in this document shall be interpreted as revising or contradicting the provisions of the UNM Faculty Handbook.

III. Voting Faculty
All faculty holding a ≥0.5 appointment in CCB shall be eligible to vote on department matters, consistent with Policy A51 in the Faculty Handbook, section 1.

Sec. 1(a) Membership: The University Faculty shall consist of the Professors, Associate Professors, Assistant Professors, Lecturers, and Instructors, including part-time and temporary appointees. The President of the University, Vice President for Academic Affairs, Vice President for Student Affairs, Vice President for Research, Vice President for Business and Finance, Associate Vice President for Computer and Information Resources and Technology, Director of the Medical Center, Deans of Colleges and Schools, Dean of Graduate Studies, Dean of Students, Dean of the University College, Dean of Admissions and Records, Registrar, Dean of Continuing Education and Community Services, Director of the Center for Graduate and Upper Division Programs Studies at Los Alamos, Director of the Center for Graduate Studies at Santa Fe, Dean of Library Services, Commanding Officers of the ROTC Units, and the Secretary of the University shall be ex-officio members of the Faculty whether or not they are actively engaged in teaching.

(b) Voting Faculty: Members of the University who are eligible to vote shall include all full-time members of the University Faculty holding professorial rank (instructors, assistant professors, associate professors, and professors) or lectureships. No person holding an interim or temporary appointment on the teaching staff shall be a member of the Voting Faculty unless he or she be a member ex officio or on an initial term appointment. The ex officio members of the University Faculty as listed in Sec.1(a) shall be ex officio members of the Voting Faculty.
After the University approved part-time tenured/tenure-track faculty appointments (1998), voting privileges at all organizational levels were extended to this group of faculty members.

Visiting and temporary faculty do not vote, nor do untenured faculty vote on tenure decisions, nor do faculty vote on promotion to ranks above their own.

IV. Guidelines for Meetings of the CCB Faculty

Schedule- Regular faculty meetings will be held once every four weeks at a minimum during the academic year. A regular one-hour time slot will be set aside for meetings during which no departmental courses are taught. The chair may call additional regular meetings as needed, using the same time slot when possible. Emergency meetings to deal with urgent items may be held in other time slots if necessary. All committee and faculty meetings will be conducted in a civil and professional manner in accordance with UNM policy (Respectful Campus Policy, University Business and Procedures manual #2240: http://www.unm.edu/~ubppm/ubppmanual/2240.htm).

Attendance- All CCB faculty are expected to attend assigned committee and departmental faculty meetings. As a courtesy, those unable to attend will inform the committee Chair or the Department Chair, in advance, of their absence.

Agenda- A meeting agenda will be distributed to all faculty 24 hours in advance of each regular meeting. Faculty wishing to place an item on the agenda should contact the departmental administrator at least 48 hours before the meeting. The agenda will indicate if an item may require a vote or is for discussion only. No item will be voted on at a regular meeting unless it has been discussed at a previous meeting. The text of proposed motions should be distributed to the entire faculty at least 48 hours before the meeting. The chair may add urgent, last-minute agenda items for emergencies only.

Conduct- Meetings will be conducted by the chair or, in the chair’s absence, the associate chair. All regular meetings will contain a time for general comments, including requests for topics to discuss at the next meeting. Each faculty member will have an opportunity to speak to the topic in each discussion, although the chair may limit the time per speaker.

Voting- Decision by consensus is the general goal, but may not always be possible. Votes to modify this handbook, to change degree requirements or other substantial issues as designated by the chair must have a 2/3 majority (of those voting yes or no) for approval. Personnel decisions and other especially important decisions (as designated by the chair) will be made by confidential written ballot. Faculty may abstain from voting if they feel the matter is outside their interests or expertise.
Summaries - A meeting summary, containing the general topics of discussion and the decisions reached, will be posted by the departmental administrator within one week after the meeting. Faculty are expected to read the summary and send any corrections to the administrator within one week of receipt.

V. Guidelines for the Chair

Appointment The Dean of Arts and Sciences shall appoint a chair after consultation with departmental faculty, as outlined in Section C40 of the UNM Faculty Handbook (http://www.unm.edu/~handbook/C40.html).

Role of the Chair The department Chair has several overlapping roles
Administrator The Chair is responsible for the day to day operations of the department. This role includes, but is not limited to, personnel matters (faculty recruitment and hiring, evaluations, disciplinary actions, and delegation of responsibilities), teaching workloads (class scheduling, instructor assignments, peer evaluations), and budgetary oversight (resource allocation) as well as supervising departmental employees and implementing procedures in accordance with university requirements

Department Representative As the public face of the Department, the Chair represents the interests, expertise, needs, and opinions of the Department’s entire faculty, staff, and students to other departments, other Chairs, the Dean and other relevant UNM administrators. The Chair also communicates the department’s mission, strengths, and needs to the outside world as needed and as opportunities arise.

Facilitator It is the Chair’s role to create a working environment in which faculty interactions and collaborations may flourish; in which faculty are provided the clerical, fiscal, and administrative support necessary to successfully attain both their own and institutional goals; and in which all students are afforded the opportunities to successfully complete their academic classes and programs.

Leader The Chair is expected to introduce and foster new ideas into departmental discussions, and fashion consensus among differing viewpoints. This includes leading the department as it reaches consensus about its mission. The Chair should foster innovation and creativity throughout the teaching, research, and service missions of the department.

Chair Behavior The Chair occupies a position of authority that carries with it expectations regarding modes of behavior. It is expected that the Chair will conduct all business of the department in an objective manner and that resources will be allocated fairly and proportionately to all areas and objectives. To that end, given that the research active faculty members are the
sole contributors to the department overhead account, any financial decisions involving this account should be made in conjunction with at least the Advisory Committee. In addition, it is assumed that when faculty, staff and students request a confidential discussion with the Chair that the discussions will be kept confidential excepting for those situations that may require official reporting. The Chair will in all instances conduct himself or herself in a manner that precludes any perception of favoritism or targeted dislike or disdain.

**Duties and responsibilities** The faculty handbook and university regulations describe many of the responsibilities and duties of a department chair. This list is not intended to repeat or replace those documents. The CCB department chair-

- Hires and supervises staff, directly or indirectly
- Hires and supervises faculty
- Provides annual evaluations of faculty and staff
- Oversees tenure, promotion and re-appointment processes
- Schedules classes and makes teaching assignments
- Presides over faculty meetings
- Appoints the associate chair and other faculty administrative positions as needed
- Appoints chairs and members of standing committees
- Allocates department-controlled space
- Allocates the departmental budget
- Represents the department within and outside the university

**VI. Guidelines for the Advisory Committee**

**Purpose** The Advisory Committee advises the chair on substantive policy, procedural and personnel decisions. As such, it is important that the committee enjoys the confidence of the faculty as a whole and is able to represent a variety of viewpoints in discussions with the chair.

**Duties** The committee will meet at least monthly during the academic year, meetings to be chaired by the department chair, associate chair or a designated member of the AC. The committee will be asked to provide advice on:

- Membership on ad hoc committees
- Faculty salary increments during years when merit raises are available
- Substantial policy, procedure or curriculum proposals, whether originating from the chair or from other committees

The committee may also be asked to provide advice on other issues and to prepare or evaluate reports on subjects of broader import.
**Composition** The advisory committee will consist of four faculty members serving staggered 2-year terms. All departmental faculty are eligible to serve, but the department chair will not be a member of the committee.

**Selection** Two committee members will be elected each May to begin a 2-year term the following academic year. The date of election will be announced at least two weeks in advance, and candidates should be nominated (including self-nominated) at least one week in advance. A list of nominees who have agreed to be candidates will be distributed three days in advance of the election. Each faculty member may vote for two candidates. The two candidates receiving the most votes will become members of the advisory committee.

**VII. Guidelines for Committees**

In addition to the elected advisory committee, the department will have standing committees and *ad hoc* committees to carry out various functions.

**Purpose** Standing committees may exist for multiple years, and membership should change slowly to provide continuity. They typically have regular (annual) functions and special charges for certain years, and the committee chair may be required to report on these to the departmental faculty and chair. Typical standing committees might include an undergraduate studies committee, a graduate studies committee and a building/facilities committee. *Ad hoc* committees are formed for a special purpose and are discharged when that purpose is fulfilled. Examples of *ad hoc* committees include faculty search committees, tenure and promotion committees and special review committees.

**Appointment** The chair will appoint members of standing committees to three year terms, and will select one committee member as committee chair. The chair will consult with the advisory committee before appointing members and a chair for *ad hoc* committees, and the members will serve until the committee is discharged.

**Charge and scope** At the beginning of the academic year, the chair will provide each standing committee with a written charge or list of responsibilities. The charge is not intended to be an exhaustive list of required actions, but to avoid overlap or duplications with other committees or individuals. Similarly, the chair will provide each *ad hoc* committee with a written charge when it is formed.
VIII. Guidelines for Tenure Decisions

Awarding of tenure is one of the most important processes for the department, college and university. Rules which apply to all faculty members can be found in the faculty handbook Policy on Academic Freedom and Tenure where section B.4 discusses annual review, mid-probationary review and the tenure review (http://handbook.unm.edu/newhb.html). Additional information pertaining specifically to A&S can be found on the college guideline pages (http://www.unm.edu/~artsci/for-faculty/promotion-tenure.htm). Departmental guidelines cannot contradict or supersede those rules, and in case of apparent disagreement the university and college level rules must apply.

Expectations The general areas of evaluation for a successful tenure decision, set forth in the UNM faculty handbook policy on academic freedom and tenure, are:

“1.2 CATEGORIES FOR FACULTY PERFORMANCE EVALUATIONS
(a) The categories in which faculty performance will be evaluated are the following:
(1) Teaching, (2) Scholarly Work, (3) Service, (4) Personal Characteristics...
(b) In order to earn either tenure or promotion or both, faculty are required to be effective in all four areas. Excellence in either teaching or scholarly work constitutes the chief basis for tenure and promotion. Service and personal characteristics are important but normally round out and complement the faculty member’s strengths in teaching and scholarly work.”

CCB will evaluate candidates on an absolute basis; a tenure (or other personnel) decision about one candidate should be based only on the performance and promise of that candidate, not a comparison to a prior or subsequent candidate. Evaluations encompass both past performance and future promise.

In CCB, research-active faculty are expected to obtain external research funds, supervise graduate and undergraduate students and/or postdoctoral fellows, participate in departmental seminars and governance, and teach a normal load of approximately one three-unit course per semester.

Expectations for a successful tenure decision are:
(1) Teaching- The candidate has demonstrated effective classroom teaching through favorable peer and student reviews and through evidence of student learning. Student mentoring and development of course materials can also contribute to the evaluation.
(2) Research- The candidate has established an independent and internationally-recognized research program as evidenced by peer-reviewed publications, externally funded grants, presentations at inter/national scientific conferences and favorable evaluations from recognized scholars in the field. In the chemical sciences this constitutes what the Faculty Handbook calls “Scholarly Work.”
(3) Service- The candidate has provided conscientious service to the department via committee memberships and minor administrative roles, and to the profession through manuscript, proposal reviewing, or other like activities.

(4) Personal characteristics- The candidate’s interactions with faculty, staff and students have been collegial, professional and considerate.

**Mentoring and evaluation of probationary faculty** Normally, the department will evaluate assistant professors annually until the 6th year, when a tenure evaluation and vote will occur. The mid-probationary review and evaluation, typically conducted the 3rd year, requires a formal file submission, vote by the faculty, and further evaluation at the college and university level. The tenure evaluation also requires a formal file submission, vote by the faculty, and further evaluation at the college and university level; only the tenure evaluation requires the participation of external, non-UNM referees to evaluate the candidate’s research program. Other written evaluations (‘annual reviews’) will be conducted by the chair in consultation with senior faculty. All evaluations will consider teaching, research and service components, and the candidate is expected to submit a file containing the relevant information for the evaluation period.

**Mentoring committee** Each probationary faculty member (candidate) will have a mentoring committee charged both with advising the candidate and with presenting the mid-probationary and tenure files to the tenured CCB faculty for discussion. The committee will have three members, two tenured CCB faculty and one tenured UNM faculty from outside of CCB. Once formed, the committee should meet with the candidate at least annually. The chair will appoint the committee members with input from the candidate. A member of the hiring committee, usually the chair, will be assigned temporary mentoring responsibilities once the new faculty member has accepted the department’s offer. At least one regular mentor should be selected by the middle of candidate’s first semester at UNM, and all three must be selected by end of the candidate’s second year. Members of the mentoring committee may be replaced at the request of either the member or the candidate.

**Candidate seminars** The candidate will present a departmental seminar at the beginning of the Fall term of the 3rd (mid-pro) and 6th (tenure) years in the department. In each case, the seminar should be viewed as an opportunity to present the candidate’s overall research program (not simply past results or a subset of overall research) to the CCB faculty and students. In each case, the seminar should include specific plans for future research. These seminars should help the faculty form opinions about the research program; it also provides an opportunity for constructive criticism and comments, especially after the 3rd year seminar.

**Peer teaching evaluations** The candidate’s teaching should be observed each term by a tenured faculty member or senior/principal lecturer selected by the chair. A teaching report will
be prepared by the observer, and may include comments on the teaching style and subject matter, student preparedness and response, course syllabus, assignments and tests, and other related topics. These reports will be provided immediately to the candidate, and then also included in the candidate’s mid-pro and tenure evaluation files, and the CCB chair(s) should ensure that a cross-section of courses taught is represented by the end of year 5.

Annual reviews General information on the annual review process can be found in section 4.2 of the Policy on Academic Freedom and tenure-

The annual evaluation file should contain a cv, written materials (manuscripts published, abstracts of presented talks and proposals submitted) from the past year, and copies of peer and student teaching reviews from the past year. In addition to this, it should include a 1-page self-evaluation and a 1-paragraph set of goals for the coming year. The review meeting will be conducted in the Spring term, and the chair should send a written letter of evaluation to the candidate within two weeks of the review. If the candidate disagrees with the letter, he or she may also submit a reply. These annual review letters are to be included in the candidate’s file for mid-probationary and tenure review.

Tenure and mid-probationary reviews Tenured CCB faculty are expected to meet to discuss each mid-probationary and tenure decision. The candidate’s file should be made available to the faculty at least four weeks before the meeting, and should contain teaching evaluations (student and peer), copies of manuscripts published and funded proposals, a list of service activities, and self-evaluations of the candidate’s teaching, research and service contributions; both short (2-page maximum) and longer (up to 15 pages) self-evaluations should be included. For tenure evaluation only, the file should include letters of evaluation from external referees, approximately half chosen by the candidate and half by the chair in consultation with senior faculty. The meeting date and time should be announced when the file is made available. Although an oral ‘straw vote’ may occur during the meeting, only written votes are considered official. These written votes using A&S recommendation forms should be submitted to the chair within two weeks of the meeting. The chair is responsible for submitting the file and all faculty votes to the Dean, along with the chair’s letter of evaluation and recommendation.

IX. Guidelines for Promotion Decisions

1. Tenure-track promotions

Promotion in rank to associate or full professor is an important process described in some detail in the UNM faculty handbook (sections B.2.2.3, 4.8.1, 4.8.3, and 4.8.6). Evaluation for promotion generally considers the same performance categories as the tenure process: teaching, scholarship, service and personal characteristics. The specific CCB requirements for promotion to Associate Professor are the same as those for the awarding of tenure, as is usual at UNM.
Although technically these are separate decisions, they are almost always made at the same time using the same dossier and the same requirements (Faculty Handbook section B.4.8.2). Promotion to Full Professor is a separate process which typically emphasizes significant research accomplishments recognized on a national and international level.

**Process:** Promotion to the rank of full professor is conducted on an absolute basis within the department, not by comparison to past or present CCB faculty. The anticipated length of service as associate professor prior to consideration for promotion to the rank of professor is at least five years. Recommendations for promotion in less time, “early promotion”, must demonstrate unusual accomplishment. The review for promotion to full professor should be requested by the candidate before the beginning of the Fall semester, and the chair will appoint a committee of three full professors to help the chair select external referees and to evaluate and present the case to departmental full professors for a vote. The vote should be completed by the end of the Fall semester and the candidate’s application file, faculty votes, and chair’s letter should be submitted to the college before the beginning of the following Spring semester (exact date determined by the college). Notification of the outcome of the review is made no later than June 30 of that year.

**Expectations:** According to the Faculty Handbook, “qualifications for promotion to the rank of professor include attainment of high standards in teaching, scholarly work, and service to the University or profession. Promotion indicates that the faculty member is of comparable stature with others in his or her field at the same rank in comparable universities. Service in a given rank for any number of years is not in itself a sufficient reason for promotion to professor.”

**2. Lecturer promotions**

Promotion in rank to senior or principal lecturer is an important process described in some detail in the UNM faculty handbook (B.2.3.2, B.3.4.2, and B.4.10.). Evaluation for promotion principally considers teaching and service; lecturers typically have no expectation of research, but research may be considered at the discretion of the candidate. Evaluation of teaching performance (including lab coordination) is expressed in a teaching portfolio which covers a) student evaluations, b) peer observations/evaluations, c) student learning assessment and d) reflective response to a, b, and c. Reflection should include past goals and should set future goals. Professional development activities should also be included (conference attendance and presentation, workshops, classes related to teaching and learning in chemistry). Service expectations are similar to that for tenured faculty, but centered on teaching-related assignments.

Promotion to the rank of senior or principal lecturer is conducted on an absolute basis within the department, not by comparison to past or present CCB faculty. The anticipated length of service as lecturer prior to consideration for promotion to senior lecturer is at least five years; length of service prior to consideration for promotion to principal lecturer is eleven years.
**Process:** A review for promotion to either rank (senior or principal) should be requested by the candidate by the beginning of a Fall semester for promotion to take effect the following summer. The chair will appoint a committee of at least three senior faculty (tenured or lecturers) to evaluate and present the case to departmental faculty. The vote should be completed by the end of the Fall semester and the candidate’s application file, faculty votes, and chair’s letter should be submitted to the college before the beginning of the following Spring semester (exact date determined by the college). Notification of the outcome of the review is made no later than June 30 of that year.

**Expectations:** According to the Faculty Handbook, senior lecturers

“...have demonstrated professional excellence and shown a conscientious interest in improving their professional skills... the rank of Senior Lecturer represents a judgment on the part of the department, School or College, and University that the individual has made and will continue to make sound contributions in their professional areas. The appointment should be made only after careful investigation of the candidate's professional and leadership accomplishments and promise.”

According to the Faculty Handbook, principal lecturers

“...have sustained consistently high standards in their professional contributions, consistently demonstrated their wider service to the University community and its mission, and shown a conscientious interest in improving their professional skills. It is expected that Principal Lecturers will continue to develop and mature with regard to their professional activities and leadership within the University.... the rank of Principal Lecturer represents a judgment on the part of the department, School or College, and University that the individual has attained and will continue to sustain an overall profile of professional excellence and engagement in the wider profession. The appointment should be made only after careful investigation of the candidate's professional and leadership accomplishments and promise.”

**X. Research Faculty**

According to the faculty handbook, research faculty titles “are appropriate for persons who are engaged primarily in research activities and have qualifications similar to those held by tenure-track faculty. They may occasionally teach or serve as members of thesis or dissertation committees... Research professors generally have extramural funding in which they are the principal investigator or for which their contribution is crucial to the funding.”

Assistant and associate research professors in Chemistry and Chemical Biology work together with a tenured faculty member, sharing lab facilities and receiving salary and other support from grants in which the tenured faculty member is PI. Full research professors are expected to provide most of their own research support, including salary, from external sources; they may work closely with tenured faculty or independently. Full research professors may co-
chair student doctoral committees with tenured faculty, subject to the same graduate program
procedures as other CCB professors. The department is not obligated to provide salary or
research facilities for research professors at any rank unless specifically negotiated.

1. Promotions
Promotion of research faculty principally considers research excellence and independent
funding; research faculty generally have minimal expectations of teaching and service, but
teaching and/or service may be considered at the request of the candidate. Research excellence
will be evaluated based on a current CV (in the standard Arts and Sciences format), statements of
research and (when appropriate) service and teaching interests, and a departmental research
colloquium. A teaching portfolio is required only if teaching is to be considered, otherwise this
is optional. Promotion to research full professor requires the candidate to demonstrate fiscal
independence, defined as providing at least 50% of their salary from external sources; research
associate professors who are paid principally through grants held by tenured faculty cannot be
promoted to research full professor.
Process: Promotion must be proposed by a tenured faculty advocate. This faculty
member will assist the research faculty member with the promotion process, speak on behalf of
the research faculty member in faculty deliberations and advocate the proposed promotion to
the rest of the regular faculty.
The standard for promotion is research excellence, which shall be evaluated and
interpreted broadly by the departmental faculty but includes scholarly publication and
professional accomplishment. Minimum time in rank should generally mirror that for the tenure
track faculty (typically five years in rank as assistant before application for promotion). Early
promotion may be considered in cases when justified, supported by the relevant voting faculty,
and approved by the Dean of the College of Arts and Sciences. The Department’s faculty
advisory committee will review and approve the submitted promotion package and make the
package available to the tenured faculty.
The tenured faculty will vote on the promotion package by written ballot following a
meeting discussing the dossier. The voting faculty will be the same faculty who are qualified to
vote on tenure and promotion decisions for tenure track faculty. For example, associate and full
professors will vote for promotion to research associate professor, while only the full professors
will vote for promotion to research professor. If the faculty vote is positive, the Department
Chair will compile his/her decision, the faculty decision, and a summary letter detailing the
faculty decision and report this to the Dean of Arts and Sciences for approval.

2. Appointment
Appointing a research assistant professor is at the discretion of the tenured faculty
member providing salary. Those hired should have similar qualifications (Ph.D., post-doctoral
experience) to assistant professors, but no faculty vote is required.
Appointing a research associate professor following nomination by the supporting tenured faculty member requires a positive vote by tenured faculty (as for promotion from assistant to associate status).

Appointing a research full professor requires nomination by a tenured full professor, demonstrated fiscal independence, and a positive vote by the full professors.

Research faculty appointments requiring a faculty vote shall be considered to have a three-year term, and may be renewed by another such vote.
Undergraduate Professional Education in Chemistry

ACS Guidelines and Evaluation Procedures for Bachelor’s Degree Programs

Spring 2015
American Chemical Society
Committee on Professional Training
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I. GUIDELINES FOR PROGRAM APPROVAL AND
STUDENT CERTIFICATION

1. Goals of Program Approval and Student Certification

Chemistry is central to intellectual and technological advances in many areas of science. The traditional boundaries between chemistry subdisciplines are blurring, and chemistry increasingly overlaps with other sciences. Unchanged, however, is the molecular perspective that lies at the heart of chemistry. Chemistry programs have the responsibility to communicate this molecular view to their students and to teach the skills necessary for their students to apply this perspective.

The American Chemical Society (ACS) promotes excellence in chemistry education for undergraduate students through approval of baccalaureate chemistry programs. ACS has charged the Committee on Professional Training (CPT) with the development and administration of guidelines for this purpose. ACS, through CPT, approves chemistry programs meeting the ACS guidelines. Approved programs offer their students a broad-based and rigorous chemistry education that provides them with the intellectual, experimental, and communication skills necessary to become successful scientific professionals. Offering such a rigorous program requires an energetic and accomplished faculty, a modern and well-maintained infrastructure, and a coherent chemistry curriculum that develops content knowledge and broader skills through the utilization of effective pedagogical approaches. ACS recognizes that the diversity of institutions and students is a strength in higher education. Thus, these guidelines provide approved programs with opportunities to develop chemistry degree tracks that are appropriate to the educational missions of their institutions.

ACS authorizes the chair of the ACS-approved program to certify graduating students who complete a bachelor’s degree meeting the ACS guidelines. Graduates who attain a certified degree must complete requirements that may in fact exceed those of the degree-granting institution, but this comprehensive undergraduate experience provides an excellent foundation for a career in the molecular sciences. An ACS-certified degree signifies that a student has completed an integrated, rigorous program including introductory and foundational course work in chemistry and in-depth course work in chemistry or chemistry-related fields. The certified degree also
emphasizes laboratory experience and the development of professional skills needed to be an effective chemist. Certification gives a student an identity as a chemist and helps in the transition from undergraduate studies to professional studies or employment.

ACS approval publicly recognizes the excellent chemistry education opportunities provided by an institution to its students. It also provides standards for a chemistry curriculum based on broad community expectations that are useful for a program when designing its curriculum or acquiring resources. The approval process provides a mechanism for faculty to evaluate their programs, identify areas of strength and opportunities for change, and leverage support from their institutions and external agencies. Faculty benefit from the commitment to professional development required of approved programs. Students benefit from taking chemistry courses from a program that meets the high standards of ACS approval, and ACS-certified graduates benefit from their broad, rigorous education in chemistry and the recognition associated with their degree.

2. Institutional Environment

An approved chemistry program requires a substantial institutional commitment to an environment that supports long-term excellence. Because the approved program exists in the context of the institutional mission, it must support the needs, career goals, and interests of the institution’s students. Competitive policies should be implemented regarding faculty salaries, duties, promotions, and tenure decisions. Similarly, in order to support a viable and sustainable chemistry program, the institutional environment must provide the attributes described in this section.

2.1 Institutional Accreditation. The institution must be accredited by the regional accrediting body. Such accreditation ensures broad institutional support in areas such as mathematics, related sciences, and the humanities.

2.2 Program Organization. The administration of the approved program should rest in a chemistry department organized as an independent unit with control over an adequate budget, faculty selection and promotion, curriculum development, and assignment of teaching responsibilities. If the program is part of a larger unit, the chemistry faculty must have reasonable autonomy over these functions.

2.3 Program Budget. An approved chemistry program requires continuing and stable financial support. The institution must have the ability and will to make such a commitment at a reasonable level that is consistent with the resources of the institution and its educational mission. Adequate support enables a program to have

- a chemistry faculty with the scientific breadth to offer the educational experiences described in these guidelines,
- nonacademic staff and resources for administrative support services, stockroom administration, and instrument and equipment maintenance,
- a physical plant that meets modern safety standards with adequate waste-handling and disposal facilities,
- resources for capital equipment acquisition and replacement along with the expendable supplies required for high-quality laboratory instruction,
- modern chemical information resources,
- support for maintaining and updating instructional technology,
- research resources for faculty and students,
- personnel support to assist with the acquisition and administration of external funding,
- support for faculty and student travel to professional meetings, and
- opportunities for professional development and scholarly growth by the faculty, including sabbatical leaves.

2.4 Minimum Number of Graduates. Initial and continuing approval requires that the program award an average of at least two chemistry degrees per year during any six-year period. There is no required minimum number of certified graduates.

3. Faculty and Staff

Faculty members are responsible for defining and executing the overall goals of the undergraduate program. The faculty facilitates student learning of content knowledge and development of professional skills that constitute an undergraduate chemistry education. An energetic and accomplished faculty is
essential to an excellent undergraduate program. An approved program therefore has mechanisms in place to maintain the professional competence of its faculty, provide faculty development and mentoring opportunities, and provide regular feedback regarding faculty performance.

3.1 Faculty. The faculty of an approved program should have a range of educational backgrounds and the expertise to provide a sustainable, robust, and engaging environment in which to educate students. In addition:

- There must be at least five full-time permanent faculty members wholly committed to the chemistry program. Most vigorous and sustainable approved programs have a larger number. Currently approved programs with fewer than five permanent faculty will have until 2025 to meet this requirement. In cases where faculty contracts are renewed on a regular basis, the individuals in these positions should hold the expectation for both long-term and full-time employment.
- At least 75% of the permanent chemistry faculty members must hold the Ph.D. or an equivalent research degree.

The collective expertise of the faculty should reflect the breadth of the major areas of modern chemistry. Because faculty members serve as important professional role models, an ACS-approved program should have a faculty that is diverse in gender, race, and ethnic background.

3.2 Adjunct, Temporary, and Part-Time Faculty. Courses leading to student certification in an approved program should be taught by permanent faculty. Programs may occasionally engage highly qualified individuals outside the regular faculty to deliver special courses or to replace permanent faculty members who are on sabbatical or other leaves of absence. The Committee strongly discourages excessive reliance on temporary or part-time faculty by an ACS-approved program and carefully reviews such situations.

3.3 Teaching Contact Hours. Contact hours are the actual time spent by faculty and instructional staff in the direct supervision of students in a classroom (face-to-face or online) or laboratory. Online activities that are developed as substitutes for classroom instruction should be assigned at least the same contact hour value as equivalent face-to-face classroom experiences. The institution’s policies about teaching contact hours should provide all faculty and instructional staff adequate time for professional development, regular curriculum assessment and improvement, contact with students outside of class, and when appropriate, supervision of research. For the purpose of these guidelines, the following two groups of faculty and instructional staff are identified, based on their teaching responsibilities:

- **Group A.** For faculty and instructional staff who teach only in the classroom or in both the classroom and laboratory, the number of contact hours must not exceed 15 total hours per week. Fifteen contact hours is an upper limit, and a significantly smaller number should be the normal teaching obligation, particularly for faculty supervising undergraduate research.

- **Group B.** For faculty and instructional staff who teach exclusively laboratory courses, the number of contact hours must not exceed 16 total hours per week.

In any given academic year, exceptions may be made for up to two individuals in Group A and two individuals in Group B above, provided that:

- The average for each individual in Group A does not exceed 15 contact hours per week during the academic year and the average for each individual in Group B does not exceed 16 contact hours per week.
- The maximum for each individual does not exceed 18 contact hours in any semester or quarter.
- The maximum contact hours for each individual are exceeded in only one quarter or semester of the academic year.

3.4 Professional Development. Institutional policies and practices should provide opportunity and resources for scholarly activities that allow faculty and instructional staff to stay current in both their research specialties and modern pedagogy in order to teach most effectively.

- The institution should provide opportunities for renewal and professional development through sabbaticals, participation in professional meetings, and other professional activities. Faculty and instructional staff should use these opportunities for improvement of instructional and research programs. Institutions should provide resources to ensure program continuity during sabbaticals and other leaves.
- Excellent programs provide formal mechanisms by which established faculty mentor junior colleagues. Proper mentoring integrates all members of the faculty and instructional staff into the culture of their particular academic unit, institution, and the chemistry profession, ensuring the stability and vitality of the program.
3.5 Support Staff. A sustainable and robust program requires an adequate number of administrative personnel, stockroom staff, and technical staff, such as instrument technicians, machinists, and chemical hygiene officers. The number of support staff should be sufficient to allow faculty members to devote their time and effort to academic responsibilities and scholarly activities.

3.6 Student Teaching Assistants. The participation of upper-class chemistry undergraduates and graduate students in the instructional program as teaching assistants both helps them reinforce their knowledge of chemistry and provides a greater level of educational support for students they supervise. If undergraduate or graduate students serve as teaching assistants, they must be properly trained and supervised.

4. Infrastructure

A modern and comprehensive infrastructure is essential to a vigorous undergraduate program. Program infrastructure must receive strong institutional support to provide sustainability through inevitable changes in faculty, leadership, and funding levels.

4.1 Physical Plant. An approved program should have classroom, teaching laboratory, research, office, and common space that is safe, modern, well-equipped, and properly maintained.

- Chemistry classrooms and faculty offices should be reasonably close to instructional and research laboratories. Classrooms should adhere to modern standards for lighting, ventilation, and comfort and have proper demonstration facilities, projection capabilities, and internet access.
- Laboratories for research and instruction in the chemical sciences must be suitable for their purpose and must meet applicable government regulations. Properly functioning and appropriate fume hoods, safety showers, eyewashes, first aid kits, and fire extinguishers must be readily available. Construction or renovation of laboratory facilities must conform to Occupational Safety and Health Administration (OSHA), national, and state regulations.
- The number of students supervised by a faculty member or by a teaching assistant in an instructional lab should not exceed 25. Many laboratories require smaller numbers for safe and effective instruction.
- Faculty and student research laboratories should have dedicated facilities appropriate for the type of work conducted in them. These facilities should permit experiments to be maintained for extended periods of time during ongoing research projects.
- The program should have access to support facilities such as machine, electronic, and glass fabrication shops to support both teaching and research.

4.2 Instrumentation. Characterization and analysis of chemical systems require an appropriate suite of modern, high quality, and properly maintained instrumentation and specialized laboratory equipment that are utilized in undergraduate instruction and research.

Approved programs must have a functioning NMR spectrometer on site that undergraduates use. The field strength and capabilities of the NMR instrumentation should support the instructional and research needs of the program. If the on-site instrument does not meet all of the program's research needs, stable arrangements must be made with proximal sites to provide ready access to appropriate NMR instrumentation.

In addition, instruments from at least four of the following five categories must be on site and used by undergraduates:

- optical molecular spectroscopy (e.g., FT-IR, fluorescence, Raman, UV-Vis)
- optical atomic spectroscopy (e.g., atomic absorption, ICP-atomic emission)
- mass spectrometry (e.g., MS, GC-MS, LC-MS)
- chromatography and separations (e.g., GC, GPC, HPLC, ion chromatography, capillary electrophoresis, SEC)
- electrochemistry (e.g., potentiometry, amperometry, coulometry, voltammetry)

Programs must maintain an additional complement of instrumentation that is adequate to support the curriculum, including undergraduate research. For example, programs might have multiple instruments from one or more of the categories listed above or additional supplemental instrumentation, which might include vacuum and inert-atmosphere systems (e.g., Schlenk line, dry box), thermal analysis (e.g., DSC, TGA), x-ray diffraction, or imaging and microscopy methods (e.g., electron microscopy, scanning probe microscopy, confocal microscopy), or biochemical instrumentation (e.g., thermocyclers,
4.3 Computational Capabilities and Software. The ability to compute chemical properties and phenomena complements experimental work by enhancing understanding and providing predictive power. Students should have access to computing facilities and use computational chemistry software.

4.4 Chemical Information Resources. A broad range of the peer-reviewed chemical literature must be readily accessible to both faculty and students.
- An approved program must provide immediate institutional access to no fewer than 14 current and archival, peer-reviewed journals whose subject matter spans the chemical sciences. At least three of the journals must have a general focus (for example, Science, JACS, Angewandte Chemie International Edition, Chemistry – A European Journal, Chemical Communications, etc.), and at least one must come from each area of analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry, and chemistry education. In addition, the library must provide timely access to journal articles that are not available on site by a mechanism such as interlibrary loan or a document delivery service.
- Students must have access to technical databases and other resources that enable development of skills in searching the literature, including structure-based searching, and support research and instructional activities.

4.5 Laboratory Safety Resources. The program must be conducted in a safe environment that is consistent with the following features:
- There must be a written chemical hygiene plan consistent with OSHA and state standards. A mechanism for harmonizing this plan with the teaching and research activities of the program is required for the establishment of a safety culture.
- Laboratory safety plans need to recognize hazards encountered in the instructional and research activities in the program. Common hazards include chemical hazards (health, physical, and environmental), extreme temperatures, high pressures and voltages, ionizing and non-ionizing radiation, and intense light sources.
- For materials and equipment that present particular hazards, specific standard operating procedures (SOPs) should be developed and incorporated into the chemical hygiene and chemical safety plans of the program.
- Hazardous waste management must be part of the chemical hygiene plan and adhere to institutional, federal, and state regulations regarding hazardous waste management and laboratory safety. This includes maintenance of proper facilities for chemical waste disposal and personnel to address this task.
- Safety information and reference materials, such as Safety Data Sheets, should be accessible from or available in the laboratories.
- Appropriate personal protective equipment must be readily available to students, staff, and faculty.
- Regularly tested and inspected eyewash and shower stations must be located in all laboratories in which such safety devices are mandated.
- Regularly tested and inspected fume hoods must be present in all laboratories that involve the use of potentially hazardous materials.
- The chemistry program must promote a safety culture by coordinating safety inspections of laboratories, receiving and analyzing accident reports, receiving emergency response training and assuring that everyone working in instructional and research laboratories is properly educated on safety issues. The mechanism for promoting a safety culture, which will often include a safety committee or safety officer, should be a collaborative endeavor with the institutional environmental health and safety office (if one exists) and the chemical hygiene officer.

4.6 Support and Resources for Transfer Students. Many students transfer among institutions during their undergraduate education, including those who start their course work at community colleges. Approved programs should be aware of the educational backgrounds and unique challenges facing transfer students. Programs should provide an advisor to assist transfer students with orientation, academic advising, and successful integration into their new institution. They should also engage in activities to encourage and ease transfer student matriculation and provide a vibrant, supportive framework for their success.
5. Curriculum

The curriculum of an approved program provides both a broad background in chemical principles and in-depth study of chemistry or chemistry-related areas that build on this background. These guidelines describe the chemistry curriculum in terms of content and development of student skills. The content areas encompass five of the traditional subdisciplines of chemistry: analytical, biochemistry, inorganic, organic, and physical, and include both small molecules and macromolecules. Student learning progresses from beginner to expert knowledge and comprises introductory, foundation, and in-depth experiences. Beyond the introductory chemistry experience, foundation experiences provide breadth of coverage across the traditional subdisciplines. Rigorous in-depth experiences build upon the foundation. Furthermore, because chemistry is an experimental science, substantial laboratory work is integral to these three levels of experience. Programs have the opportunity to design innovative curricula that meet the needs and interests of their students by defining degree tracks or concentrations requiring specified in-depth course work. The curriculum must also include experiences that develop student skills essential for their effective performance as scientific professionals (see Section 7).

5.1 Content Requirements. To provide students with an intellectual framework that covers the breadth of modern chemistry, the foundation experience of the curriculum must cover the five subdisciplines listed above. Student laboratory experiences must include at least four of the five subdisciplines.

Recognizing that the synthesis, analysis, and physical properties of small molecules give an incomplete picture of the higher order interactions that occur in macromolecular, supramolecular, mesoscale, and nanoscale systems, the principles that govern these systems must be part of the curriculum required for certified graduates. This instruction must cover the preparation, characterization, and physical properties of such systems. At least two of the following four types of systems must be covered: synthetic polymers, biological macromolecules, supramolecular aggregates, meso- or nanoscale materials. Coverage of these topics may be distributed across multiple courses, in which case it should constitute the equivalent of approximately one-fourth of a standard semester course.

5.2 Introductory or General Chemistry. The introductory or general chemistry experience plays a vital role in educating all students. The purpose of introductory chemistry course work for those students pursuing a degree in chemistry is preparation for the foundation course work. This introduction provides students with basic chemical concepts such as stoichiometry, states of matter, atomic structure, molecular structure and bonding, thermodynamics, equilibria, and kinetics. The diversity of institutions and students requires a variety of approaches for teaching general or introductory chemistry. Possible approaches range from a full-year course to a one-semester course to waiving the introductory course requirement for very well-prepared students. To accommodate all these situations, these guidelines focus on the requirements and characteristics of experiences beyond the introductory level.

To prepare students properly for the foundation laboratories, laboratories in introductory or general chemistry courses must be primarily hands-on, supervised laboratory experiences. Students need to be instructed in basic laboratory skills such as safe practices, keeping a notebook, use of electronic balances and volumetric glassware, preparation of solutions, chemical measurements using pH electrodes and spectrophotometers, data analysis, and report writing.

5.3 Foundation Course Work. Foundation course work provides breadth and lays the groundwork for the in-depth course work. Certified graduates must have instruction equivalent to a one-semester course of at least three semester credit hours in each of the five traditional subdisciplines of chemistry: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry. Programs operating on the quarter system can achieve this breadth with at least eight three-credit one-quarter courses that include the equivalent of at least one quarter of coverage in each of the five areas.

Foundation course work builds on the introductory chemistry experience. Foundation course work uses specialized books or materials that serve as an introduction to each field, rather than a general chemistry textbook. Exam questions should cover concepts in greater detail than in an introductory or general chemistry course. A student completing a foundation course should have mastered the vocabulary, concepts, and skills required to pursue in-depth study in that area.

Some areas, particularly organic and physical chemistry, have traditionally been taught as year-long courses. In these cases, the first-semester course in the sequence can be used as a foundation course and the second-semester course as an in-depth course. Integrated foundation course work may provide
exposure to multiple foundation areas of chemistry or a group of topics organized by overarching themes (for example, synthesis, characterization, and reactivity) rather than by the traditional organization of chemistry subdisciplines.

5.4 In-Depth Course Work. The curriculum required for certification must also include a minimum of the equivalent of four one-semester or six one-quarter in-depth courses and correspond to at least 12 semester or 18 quarter credit hours. Because in-depth courses build on prerequisite foundation course work, the goals of in-depth courses are both to integrate topics introduced in the foundation courses and to investigate these topics more thoroughly. Exams and other assignments associated with in-depth courses should require critical thinking and problem-solving skills. The second semester in a two-semester course sequence such as organic or physical chemistry can be considered an in-depth course.

In-depth course work could focus on content that increases a student’s understanding of one or more of the foundation areas. It could also include courses that support a special degree track (see Section 5.8). One or more of the in-depth courses may be taught in another department, but they must contain significant chemistry or chemistry-related content at a level beyond the foundation. The Committee encourages programs to integrate modern topics in chemistry such as catalysis, environmental chemistry, green/sustainable chemistry, materials science, and toxicology into the in-depth courses.

Laboratory courses provide an important aspect of in-depth course work for certified graduates. In general, associated classroom and laboratory courses (e.g., the second semester of organic chemistry lecture and laboratory) count as a single course in satisfying the requirement for four in-depth courses even if they have separate course numbers. Likewise, a laboratory that represents the first laboratory exposure to a foundational area is not considered an in-depth course. For a laboratory course to be considered as one of the four in-depth courses required for certification, it must represent an advanced laboratory experience that includes the integration of student skills and builds on the foundation laboratory experiences. In-depth laboratory experiences involve experiment design, execution, data analysis, and use of the chemical literature. In these courses, students are typically in the laboratory for at least six hours per week. Such courses may have an accompanying classroom component. No single laboratory or lecture course can be used to satisfy both foundation and in-depth requirements.

5.5 Frequency of Course Offerings. The most effective programs teach five foundation courses annually. Approved programs must teach at least four foundation courses annually, covering at least four of the five foundation areas. For programs on the quarter system, this requirement translates to teaching at least six of eight foundation courses every year. Each foundation course must be taught at least once in any two-year period. If any foundation courses are not taught annually, the program must make arrangements to ensure that students can complete the requirements for certification in four years.

While permanent full-time chemistry faculty usually teach all of the foundation courses, in some cases it may be appropriate to include courses taught by faculty outside the chemistry department. For example, a student might obtain a foundation biochemistry experience through a course taught in a biochemistry or biology department. In cases where course work in one of the foundation areas is taught by another department, the chemistry faculty must teach all of the remaining foundation courses annually.

Because in-depth courses determine the rigor of the undergraduate experience, the chemistry faculty must teach at least four semester-long or six quarter-long in-depth courses annually, exclusive of research. These courses must correspond to at least twelve semester or 18 quarter hours. The frequency of the in-depth course offerings must allow students to complete the requirements for a certified chemistry degree in four years. Although courses taken outside the chemistry program may be used to satisfy an individual student's in-depth course requirements, the program is still required to teach at least four in-depth semester (six quarter-long) courses, as defined in Section 5.4, in each academic year.

5.6 Laboratory Experience. The certified graduate must have 400 hours of laboratory experience beyond the introductory chemistry laboratory. Laboratory course work must cover at least four of the five traditional chemistry subdisciplines and may be distributed between the foundation and in-depth levels. Laboratory course work is an ideal place in the curriculum to develop the student skills described in Section 7. The laboratory experience must include synthesis of molecules, measurement of chemical properties, determination of structures, hands-on experience with modern instrumentation such as that listed in Section 4.2, data analysis, and computational modeling. Laboratory experiences should be designed to teach students to understand the operation and theory of modern instruments and use them to solve chemical problems. In
a computational chemistry laboratory experience, the students would be expected to use the same principles of experiment design, execution, and data analysis characteristic of hands-on laboratory experiences. In contrast, virtual laboratory experiences that replace activities that are traditionally performed hands-on cannot be used as part of the 400 laboratory hours.

5.7 Cognate Courses. Certified graduates must complete course work equivalent to two semesters of calculus and two semesters of physics with laboratory. The Committee strongly recommends a calculus-based physics curriculum and study of multivariable calculus, linear algebra, and differential equations.

5.8 Degree Tracks or Concentrations. A degree track used to certify graduates is a specialized, faculty-designed curriculum meeting the foundation, in-depth, and laboratory requirements. Degree tracks offer the opportunity to incorporate emerging areas of chemistry, make use of local expertise, and align with faculty and student interests. The faculty is responsible for defining degree tracks for its program. While the ACS approves chemistry programs, it does not approve specific degree tracks developed by individual chemistry programs. Consequently, if programs develop additional degree tracks, they may certify graduates from these tracks so long as the students meet the requirements for certification.

A degree track can broadly cover the field of chemistry or focus on a specific chemistry subdiscipline or chemistry-related multidisciplinary area. A chemistry degree track might require the second semesters of organic and physical chemistry, along with the equivalent of two semesters of in-depth electives (which can include undergraduate research). More specialized tracks might provide greater depth of instruction focused on a chemistry area such as advanced organic synthesis, computational chemistry, biochemistry, or chemical measurement science. Examples of multidisciplinary tracks include chemical education, chemical physics, environmental chemistry, forensic chemistry, materials science, medicinal chemistry, polymer chemistry, or other specialties. Degree tracks might also require additional courses, either within the chemistry program or offered in another department, which would not count as in-depth courses because they do not have sufficient chemistry content that builds on the foundation course work.

5.9 Pedagogy. An approved program should use effective pedagogies in classroom and laboratory course work. Programs should teach their courses in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles. Additionally, a program should provide opportunities for faculty to maintain their knowledge of effective practices in chemistry education and modern theories of learning and cognition in science. An approved program should regularly review its pedagogical approaches to ensure that they promote student learning and build the skills needed to be an effective professional.

Faculty should incorporate pedagogies that have been shown to be effective in undergraduate chemistry education. Examples include problem- or inquiry-based learning, peer-led instruction, learning communities, and technology-aided instruction such as the use of personal response systems and flipped or hybrid classes. Laboratory work provides a particularly attractive opportunity for inquiry-driven and open-ended investigations that promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery.

5.10 Capstone Experiences. Certified graduates should be provided with an integrative experience that requires them to synthesize the knowledge and skills introduced across the curriculum. Such experiences provide a bridge between the students’ academic and future professional activities. These experiences can take many different forms. An important aspect of this integrative experience is the opportunity it provides programs to assess the ability of students to integrate knowledge, use the chemical literature, and demonstrate effective communication skills. Such assessments typically involve some combination of written or oral exams, required presentations, and written reports.

These integrative experiences could be provided in an existing upper-level, designated capstone course (e.g., senior seminar) or distributed among several courses taught in the chemistry department. Typically, a stand-alone capstone course could not be used to fulfill the in-depth course requirement. Mentored teaching also provides an excellent opportunity for students to integrate their knowledge and skills, as does an independent research experience that also requires a research report and presentation of the student’s results.

5.11 Online and Virtual Instruction. Classes taught partially or wholly online should provide at least the same skill development and content as the corresponding wholly face-to-face experience. Programs should ensure that
students in such courses have adequate access to faculty and instructors and opportunities for collaboration with peers. Faculty contact-hour credit for virtual and online instruction should be at least equivalent to the corresponding classroom experience.

Chemistry is an empirical science that requires the safe and effective physical manipulation of materials, equipment, and instrumentation. This hands-on expertise cannot be developed through virtual laboratory exercises. Virtual labs may supplement hands-on laboratory exercises, but they must not replace them (see also Section 5.6).

6. Undergraduate Research

Undergraduate research allows students to integrate and reinforce chemistry knowledge from their formal course work, develop their scientific and professional skills, and create new scientific knowledge. A vigorous research program is also an effective means of keeping faculty current in their fields and provides a basis for acquiring modern instrumentation. Original research culminating in a comprehensive written report provides an effective means for integrating undergraduate learning experiences and allows students to participate in the advancement of science.

Conducting undergraduate research with a faculty advisor allows the student to draw on faculty expertise and encourages a student-faculty mentor relationship. The research project should be envisioned as a component of a publication in a peer-reviewed journal. It should be well-defined, stand a reasonable chance of completion in the available time, apply and develop an understanding of in-depth concepts, use a variety of instrumentation, promote awareness of advanced safety practices, and be grounded in the primary chemical literature.

Research can satisfy up to four semester credit hours or six quarter credit hours of the in-depth course requirement for student certification and can account for up to 180 of the required 400 laboratory hours. A student using research to meet the ACS-certification requirements must prepare a well-written, comprehensive, and well-documented research report, including safety considerations where appropriate. Thorough and current references to peer-reviewed literature play a critical role in establishing the overall scholarship of the report. Although oral presentations, poster presentations, and journal article co-authorship are valuable, they do not substitute for the student writing a comprehensive report.

Research performed during the summer or performed off-campus, even though it might not receive academic credit, may count toward student certification. In such cases, the student must prepare a comprehensive written report that a faculty member of the home institution evaluates and approves.

7. Development of Student Skills

In order to prepare students to enter the workforce or postgraduate education, programs must provide experiences that go beyond chemistry content knowledge to develop competence in other critical skills necessary for a professional chemist. Faculty mentoring is another key component of student development because it helps students gain confidence and provides guidance about career planning and networking. Approved programs should have an established process by which they assess the development of student skills. A capstone experience (as described in Section 5.10) provides an excellent opportunity for this assessment. In addition, either dedicated courses or integration of learning opportunities throughout the curriculum can be used to develop and assess student skills.

7.1 Problem Solving Skills. An important goal of chemistry education is to provide students with the tools to solve problems. Students should be taught how to define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, understand the fundamental uncertainties in experimental measurements, and draw appropriate conclusions. Throughout the curriculum, students should be challenged to apply their understanding of all chemistry subdisciplines and use appropriate laboratory skills and instrumentation to solve problems.

7.2 Chemical Literature and Information Management Skills. Essential student skills include the ability to retrieve information efficiently and effectively by searching the chemical literature, evaluate technical articles critically, and manage many types of chemical information. Students must be instructed in effective methods for performing and assessing the quality of searches using keywords, authors, abstracts, citations, patents, and structures/substructures.
The program should provide ready access to technical databases with sufficient depth and breadth of the chemical literature for effective searching. Students’ ability to read, analyze, interpret, and cite the chemical literature as applied to answering chemical questions should be assessed throughout the curriculum. Instruction should also be provided 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. Undergraduate research and/or individual or group projects provide excellent opportunities for development and assessment of literature searching and information management skills. A stand-alone course can be an effective means of imparting information-retrieval skills, though such a course usually would not qualify as an in-depth course.

7.3 Laboratory Safety Skills. Programs must instruct students in the aspects of modern chemical safety appropriate to their educational level and scientific needs. Approved programs need to promote a safety-conscious culture in which students demonstrate and apply their understanding of the concepts of safe laboratory practices. The promotion of safety awareness and skills must begin during the first laboratory experience and should be incorporated into each lab experience thereafter. Students must undergo general safety instruction as well as lab-specific instruction before beginning undergraduate research. Classroom and laboratory discussions need to stress safe practices and should actively engage students in the evaluation and assessment of safety risks associated with laboratory experiences. Safety understanding and skills must be developed and assessed throughout the curriculum.

Programs should provide students with training that allows them to:

- carry out responsible disposal techniques
- comply with safety regulations
- properly use personal protective equipment to minimize exposure to hazards
- understand the categories of hazards associated with chemicals (health, physical, and environmental)
- use Safety Data Sheets (SDSs) and other standard printed and online safety reference materials

- recognize chemical and physical hazards in laboratories, assess the risks from these hazards, know how to minimize the risks, and prepare for emergencies.

7.4 Communication Skills. Effective communication is vital to all professional chemists. Speech and English composition courses alone rarely give students sufficient experience in oral and written communication of technical information. The chemistry curriculum should include critically evaluated writing and speaking opportunities so students learn to present information in a clear and organized manner, write well-organized and concise reports in a scientifically appropriate style, and use relevant technology in their communications. Because chemistry is a global enterprise, knowledge of one or more foreign languages or an international experience can be a valuable asset to chemistry students and add greatly to a student’s ability to communicate with other chemists worldwide.

7.5 Team Skills. Solving scientific problems often involves multidisciplinary teams. The ability to work in such teams is essential for a professional chemist. Programs should incorporate team experiences into classroom and laboratory components of the chemistry curriculum, thus providing opportunities for students to learn to interact effectively in a group to solve scientific problems and work productively with a diverse group of peers. Effective group experiences provide students with the opportunity to develop both leadership and team skills.

7.6 Ethics. Ethics should be an intentional part of the instruction in a chemistry program. Students should be trained in the responsible treatment of data, proper citation of others’ work, and the standards related to plagiarism and the publication of scientific results. The curriculum should expose students to the role of chemistry in contemporary societal and global issues, including areas such as sustainability and green chemistry. As role models, faculty should exemplify responsible conduct in their teaching, research, and all other professional activities.
8. Program Self-Evaluation

An approved program should regularly evaluate its curriculum and pedagogy, faculty development opportunities, and infrastructure needs relative to the program’s teaching and research mission. Self-evaluation is a continual process that enables programs to both introduce change in a deliberate way and improve overall effectiveness. Steps in the self-evaluation process include identifying the goals of the program, collecting and analyzing data to determine if these goals are being met, implementing changes as needed to meet the program goals, and then, after an appropriate period of time, beginning the process anew. Thoughtful and thorough self-evaluation can lead to improved or modernized course content or pedagogy, identification of areas in which the curriculum may be strengthened and student outcomes improved, and increased support for professional development and scholarly activities of faculty. Such evaluation can also provide a strong infrastructure to support the educational and scientific missions of the program.

9. Certification of Graduates

The chair of an approved program certifies those graduates receiving a baccalaureate degree consistent with these guidelines. Students usually receive certification when they complete the baccalaureate degree. It is also possible to certify students who initially obtain a non-certified baccalaureate degree from an approved program and subsequently complete additional study in an ACS-approved program to qualify for certification. The Office of Professional Training provides certificates for certified graduates.

II. APPROVAL PROCESS AND REVIEW PROCEDURES

1. Membership of the Committee

The CPT has 17 members. The ACS Board of Directors and the president of the Society with the advice of the ACS Committee on Committees jointly appoint 16 voting members. There is also one nonvoting staff Secretary. One voting member serves as an appointed chair and one serves as an elected vice chair. Initial appointments are usually for a three-year term, and reappointment for up to a total of three 3-year terms of service is possible. The Committee typically retains one or more former members or appoints individuals with special expertise as nonvoting consultants. Members of CPT are experienced educators and scientists from all areas of the country, chosen to represent different fields of chemistry and reflect much of the breadth of the chemistry community. The Secretary communicates the results of all reviews conducted by CPT and consults with faculty and administrators about guidelines and procedures related to ACS approval.

2. Costs Associated with the CPT and the Approval Program

The Society does not charge academic institutions for the evaluation of the chemistry program, including site visits by Visiting Associates of CPT (Section 8).

3. Initial Approval Process

The ACS, through CPT, establishes the recommendations and requirements for approval of bachelor’s degree programs in chemistry and policies for administering the approval process. The chemistry faculty should conduct a self-study to determine the program’s readiness to begin the approval process. The following flowchart summarizes the steps of the initial approval process, and the accompanying text describes each of the steps in the flowchart.
3.1 **Pre-Application.** The chemistry program completes a pre-application form, which is available on the CPT website, and submits it during the time periods identified on the pre-application web page.

3.2 **CPT Review.** The Committee reviews the pre-application form within two months of the submission deadline.

3.3 **Response.** The Secretary of the Committee reports the outcome of the review to the department chair by letter. Two outcomes are possible.
   1) *The program does not meet* the requirements for ACS approval that are covered by the pre-application form. The letter identifies the deficiencies and instructs the program to submit a new pre-application form after addressing the areas of noncompliance.
   2) *The program meets* the requirements for ACS approval covered by the pre-application form. The Committee invites the department to submit a full application package.

3.4 **Complete and Submit Application Package.** The program completes a comprehensive self-study questionnaire and provides supporting documentation including course syllabi, examinations, and student research reports (when research is required). The ACS staff check the package for completeness and assign the application for review by the Committee at the next ACS national meeting.

3.5 **Conference with CPT.** The chair of the department applying for approval is expected to meet with the Committee to discuss the chemistry program and answer questions about certain aspects of the application package. If the chair of a combined department is not a chemist, a chemistry faculty member must attend the conference. Additional chemistry faculty members or administrators may also meet with the Committee. The Secretary of CPT communicates the outcome of CPT’s review to the chair of the department that administers the chemistry program. Three outcomes are possible.
   1) *The Committee agrees that the program is ready for a site visit* (Section 3.8) by Visiting Associates. (Section 8)
   2) *The Committee defers a decision* pending clarification of certain aspects of the application. (Sections 3.6, 3.7)
   3) *The Committee withholds approval of the program.* (Section 3.13)
3.6 Clarify Specific Issues. The program must clarify the specific issues identified in the letter from the Secretary of CPT and submit a response by the deadline given in the letter. This step may only be taken once following submission of an application for approval.

3.7 CPT Review. ACS staff verifies that the information submitted by the applicant is complete and schedules the application for review at the next regular CPT meeting. Two outcomes are possible.

1) *The Committee agrees that the program is ready for a site visit* (Section 3.8) by Visiting Associates. (Section 8)
2) *The Committee withholds approval of the program.* (Section 3.13)

3.8 Site Visit. The Secretary of CPT reports the decision to proceed with a site visit by letter to the chair of the department that administers the chemistry program. The president (or chief administrative officer) of the institution must then invite ACS to make a site visit. Two Visiting Associates will make the site visit, which typically is spread over two days. The ACS pays all expenses of the site visitors. ACS staff provide the site visitors with background information and instructions from the Committee. The president or chief administrative officer of the institution must be available to meet with the site visitors. The site visitors submit a written report to the Secretary of CPT within one month following the visit. For more information on Visiting Associates, see Section 8.

3.9 CPT Review of Site Visit Report. CPT reviews the written report on the site visit at the first regular meeting after it is received. Three decisions are possible after this review.

1) *The Committee approves the chemistry program.* (Section 3.12)
2) *The Committee requests additional or updated information.* (Sections 3.10, 3.11)
3) *The Committee withholds approval of the program.* (Section 3.13)

3.10 Update Specific Issues. The program must clarify or update the specific issues identified in the letter from the Secretary of CPT to the chair of the department administering the chemistry program and submit a response by the deadline given in the letter. This is not an iterative step and occurs only once following the site visit.

3.11 CPT Review. CPT reviews the program’s report describing the resolution of the specific issues. Two decisions are possible after this review.

1) *The Committee approves the chemistry program.* (Section 3.12)
2) *The Committee withholds approval of the program.* (Section 3.13)

3.12 Approve. The Secretary of CPT writes to the president of the institution and the chair of the department that administers the chemistry program to report this decision. The Committee will post the name of the institution on the list of ACS-approved programs on the ACS website. An approved program must satisfy the reporting requirements described in Sections 4 and 5. Failure to comply with the annual and periodic review requirements will lead to probationary action. (Section 6)

3.13 Withhold Approval. The letter from the Secretary of CPT describes the areas of noncompliance. This letter is sent to the chair of the department administering the chemistry program with a copy to the president or chief administrative officer. After addressing these concerns, the program returns to the pre-application step of the approval process. The institution may appeal this decision as described in Section 7.

4. Annual Review

Approved programs must report annually to the Committee on the number of degrees granted by the chemistry program, information on graduates at all degree levels, the certification status of the baccalaureate graduates, and supplemental information on the curriculum and faculty. The Family Educational Rights and Privacy Act (FERPA) allows institutions to provide the names, gender, and graduation dates of all graduates to CPT. The Committee reviews the report for completeness and consistency with the guidelines and may request additional information from the program. The Committee summarizes and publishes the statistical information about the numbers of graduates at the various degree levels each year.
5. Periodic Review

To ensure compliance with the ACS guidelines, approved programs must submit a periodic report about their program using a form provided by CPT. The adjacent flowchart summarizes the steps of the review process, and the accompanying text describes each of the steps in the flowchart.

5.1 Request for Periodic Report. The Secretary of CPT contacts the chair of the department that administers the ACS-approved chemistry program with instructions for completing the report. A report form with questions on all components of the ACS guidelines, a checklist of supporting documents to be submitted, and a copy of the letter reporting the final outcome of the previous review will be provided. Among the supporting documents that may be requested are copies of specific course syllabi, examinations, and student research reports. Approved programs must submit a periodic report at least every six years. In cases where programs have been given an extended period of time to address significant issues, the next periodic report will be requested no sooner than 12 months after the outcome of the previous review has been communicated to the chair of the department.

5.2 Program Submits Report. The program must respond by the deadline provided in the letter from the Secretary.

5.3 Staff Screening. An ACS staff member checks the periodic report package for completeness and corresponds with the department chair to obtain any missing or other information as authorized by CPT.

5.4 CPT Review. The Committee reviews the periodic report at one of its three yearly meetings. Three outcomes are possible.

1) The Committee requests more information. This is not an iterative step and may occur only once following the initial submission of the periodic report. (Section 5.5)

2) The Committee determines that the chemistry program is not in compliance with the requirements specified in the guidelines or has not adequately addressed the recommendations from the previous periodic review. (Section 5.6)

3) The Committee continues approval. (Section 5.12)
5.5 Request more information. The CPT members may find that essential information is missing from the report package or clarification of ambiguous information is needed. The response is returned to CPT for review and a decision of continue approval or noncompliance is made.

5.6 Comments to Program. The Secretary of CPT identifies the area(s) of noncompliance in a letter to the chair of the department, including a reasonable timeframe for response as established by the Committee.

5.7 Response from Program. The program must report to CPT on the measures taken to address the deficiencies by the deadline provided in the letter from the Secretary.

5.8 CPT Review. The Committee reviews the program’s response at the first possible meeting after receiving it. Two outcomes are possible.
1) Continue approval. (Section 5.12)
2) Probation. (Section 5.9)

5.9 Probation. If the deficiencies have not been corrected, CPT places the chemistry program on probation. The Secretary of CPT communicates this decision and the areas of noncompliance in a letter to the president (or chief administrative officer) of the institution and the chair of the department that administers the chemistry program. The probation decision is confidential between CPT and the institution. During probation, the institution remains on the list of ACS-approved schools, and the department chair may continue to certify graduates who have satisfied the requirements as specified in the guidelines.

5.10 Response from Program. The probationary period normally lasts from 12 to 18 months. The institution must provide a written report that describes how it has corrected all of the areas of noncompliance, including supporting documentation as appropriate. Either the chair of the department administering the chemistry program or a member of the administration may submit the response to the Secretary of CPT before the end of the probationary period.

5.11 CPT Review. The Committee reviews the program’s response at the first regular meeting after receiving it. In some circumstances, CPT may request a site visit by Visiting Associates (Section 8). Two outcomes are possible.
1) Continue approval. (Section 5.12)
2) Withdraw approval. (Section 5.13)

5.12 Continue Approval. 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 (or chief administrative officer) of the institution. The Committee may identify aspects of the program that must be addressed as part of the next periodic review. Failure to respond adequately may lead to a determination of noncompliance in the future. The letter may also contain CPT’s suggestions for further development of the chemistry program. Under certain circumstances, CPT may request a shorter review cycle.

5.13 Withdraw Approval. If the program does not meet all of the requirements for ACS approval by the end of the probationary period, CPT withdraws approval of the chemistry program. The Secretary of CPT reports this outcome in a letter to the president (or chief administrative officer) of the institution and the chair of the department responsible for administering the chemistry program. The institution may appeal this decision as described in Section 7. The name of the institution will be removed from the published list of ACS-approved schools, and the chair may no longer certify graduates after the period for submitting an appeal has elapsed.

If a previously approved program wishes to re-apply for ACS approval within 12 months following the letter withdrawing approval, the program is not required to follow the regular application procedure. The program must submit a request for reinstatement to the Committee accompanied by a completed periodic report package for the current year. The possible outcomes of this review will be approval or withhold approval. The normal appeal procedure will still apply. (See Section 7)

In cases where a chemistry program submits a request to have ACS approval withdrawn, CPT will act to withdraw approval at the next regular meeting of the Committee. No probation period will be imposed. The normal appeal procedure will still apply. (See Section 7)
6. Administrative Probation

The Committee may place an ACS-approved program on probation if it does not comply with any of the following administrative requirements for maintaining approval:

- Submission of a periodic review report by the deadline.
- Submission of additional information requested during CPT review of a periodic report.
- Completion of an annual report by the deadline.

The chair of the department responsible for administering the chemistry program receives two warnings that the program has missed the deadline before the Secretary of CPT contacts the president (or chief administrative officer) of the institution. The Secretary of CPT notifies the president that the chemistry program does not comply with the requirements for maintaining approval and allows 30 days to correct the situation before placing the program on administrative probation. Administrative probation lasts no longer than 60 days. During administrative probation, programs retain approval and may certify graduates. The Committee withdraws approval of any program that fails to submit the required report or information within the 60-day period.

7. Appeal of an Adverse Decision

An institution may petition for review of an adverse decision (withhold or withdrawal of approval) if it believes that the Committee did not have access to all of the necessary evidence, has not adhered to its own established policies and procedures, or has failed to consider all of the evidence and documentation presented during the evaluation. The petition must reach the Committee within 60 days following the date of the letter advising the institution of the adverse decision. Following the Committee’s review of the petition, the institution must provide any additional information and documents in support of the petition by the provided deadline, typically no more than six months. After receiving the petition and supporting information, the Committee reviews the matter at its next regular meeting, which may include a conference with representatives of the institution if desired by either the institution or the Committee. After the meeting and deliberation, the Secretary of CPT reports the Committee’s findings to the president of the institution and the chair of the department that administers the chemistry program.

Any action of any Society unit is always subject to review by the Society’s Board of Directors, which has full legal responsibility for all Society activities.

7.1 Appeal of Withdraw Approval. A program undergoing its periodic review may follow the procedures described above to appeal this decision. Two outcomes of the appeal are possible.

1) The Committee continues approval. (Section 5.12)
2) The Committee affirms the decision to withdraw approval. (Section 7.3)

7.2 Appeal of Withhold Approval. A program applying for approval may follow the procedures described above to appeal this decision. Three outcomes of the appeal are possible.

1) The Committee approves the chemistry program. (Section 3.12)
2) The Committee agrees that the program is ready for a site visit (Section 3.8) by Visiting Associates. (Section 8)
3) The Committee affirms the decision to withhold approval. (Section 7.3)

7.3 Independent Appeals Board. Every institution has the right to appeal the Committee’s final decision to an independent Appeals Board convened for that purpose. The Society’s president and the chair of its Board of Directors will appoint an Appeals Board, consisting of three individuals who are not members of the Committee, to hear the appeal. No further appeal is available after the action of the Appeals Board.

8. Visiting Associates

The Committee selects Visiting Associates who are experienced educators and scientists familiar with the ACS guidelines and the administrative and technical aspects of conducting a successful chemistry program. In the selection of the Visiting Associates, the Committee makes every effort to eliminate any possibility of bias or conflict of interest. The Committee periodically holds meetings with Visiting Associates to brief them on guidelines policy and evaluation procedures. Visiting Associates receive comprehensive and detailed instructions on CPT’s expectations for the site visit that also are sent to the chair of the department to aid in preparation for the visit. In addition, the Associates receive confidential comments from CPT that describe
aspects of the program that should receive careful attention during the site visit and in the site visit report. Finally, Visiting Associates serve as fact-finders for CPT and do not fill the role of external consultants who might advise the faculty on the development of the chemistry program.

9. Confidentiality

The information provided to the Committee and all related discussions and correspondence between the Committee and an institution are solely for the confidential use of the Committee. In the event that an institution appeals a Committee decision, the Committee provides the information necessary for the proper conduct of the appeal to the Appeals Board.

The Committee communicates all decisions to the chair of the department that administers the chemistry program. In the case of initial approval, continued approval, report on a site visit, probation, withdrawal of approval, and appeals, the Committee also informs the president (or chief administrative officer) of the institution. These communications summarize the reasons for the decisions made by the Committee.

In its annual published reports, the Committee identifies those institutions whose programs are currently approved as meeting the ACS guidelines for undergraduate professional education in chemistry. These annual reports also summarize statistical information provided by each institution about its chemistry graduates. Otherwise, the Committee does not publish any additional information about a particular program or evaluation.

10. Complaints

Any administrative official of an institution, department chair, faculty member, student, or other person who disagrees with one or more of the policies, procedures, or activities of the Committee and who wishes to present a complaint should do so in an appropriately documented letter to the Committee Secretary. The same procedure is to be followed should the complaint allege failure of an approved institution to adhere to the ACS guidelines or allege that there is a situation tending to jeopardize the quality and vitality of a program at an approved institution. In both cases, the Committee will evaluate the matter and take actions where appropriate.

APPENDIXES

A. The Formal Mandate of the Committee on Professional Training

A resolution of the ACS Council established the Committee on Professional Training in 1936, and the Committee published the first edition of the guidelines for approval of undergraduate programs in 1939. In 1968, the Committee became a Joint Committee of the ACS Board and Council, reporting to both. In 1979, the Society codified the responsibilities of the CPT in ACS Bylaw III,3(h):

1) The SOCIETY shall sponsor an activity for the approval of undergraduate professional programs in chemistry. The Committee on Professional Training, constituted as an Other Joint Board-Council Committee under this Bylaw, shall act for the Board and Council in the formulation and implementation of the approval program with published criteria and/or guidelines, as well as published evaluation policies and procedures.

2) The goals of the approval program shall be inter alia:
   a. promoting and assisting in the development of high standards of excellence in all aspects of postsecondary chemical education, and undertaking studies important to their maintenance,
   b. collecting and making available information concerning trends and developments in modern chemical education, and
   c. cooperating with the SOCIETY and other professional and educational groups having mutual interests and concerns.

3) Institutions may petition for review of adverse evaluation decisions to an established Appeals Board consisting of three members of the SOCIETY, not members of the Committee, appointed jointly by the President and the Chair of the Board.
B. Members of the Committee on Professional Training

CPT Members – 2015

Dr. Edgar A. Arriaga, University of Minnesota-Twin Cities
Dr. Ronald Brisbois, Macalester College
Dr. Michelle O. Claville, Hampton University
Dr. Ron W. Darbeau, McNeese State University, Vice Chair 2013
Dr. Steven A. Fleming, Temple University (Committee Associate)
Dr. Suzanne Harris, University of Wyoming, Vice Chair 2009 (Consultant)
Dr. Bob A. Howell, Central Michigan University
Dr. Jeffrey N. Johnston, Vanderbilt University
Dr. Kerry K. Karuikstis, Harvey Mudd College
Dr. Laura L. Kosbar, IBM T.J. Watson Research Center
Dr. Clark R. Landis, University of Wisconsin-Madison, Vice Chair 2015
Dr. Cynthia K. Larive, University of California, Riverside, Vice Chair 2007-08, Chair 2009-11 (Consultant)
Dr. Stephen Lee, Cornell University
Dr. Anne B. McCoy, The Ohio State University, Vice Chair 2011, Chair 2012-14
Dr. Lisa McElwee-White, University of Florida
Dr. Christopher R. Meyer, California State University, Fullerton
Dr. Lee Y. Park, Williams College, Vice Chair 2010 (Consultant)
Dr. Richard W. Schwenz, University of Northern Colorado
Dr. Joel I. Shulman, University of Cincinnati (Consultant)
Dr. Greg M. Swain, Michigan State University
Dr. Thomas J. Wenzel, Bates College, Vice Chair 2014, Chair 2015
Dr. George S. Wilson, University of Kansas (Consultant)

Former CPT Members Who Participated in the Development of the Guidelines

Dr. Ron C. Estler, Fort Lewis College, Vice Chair 2012
Dr. Joseph S. Francisco, University of Nebraska-Lincoln
Dr. Carlos G. Gutierrez, California State University, Los Angeles
Dr. Scott C. Hartsel, University of Wisconsin-Eau Claire
Dr. John W. Kozarich, ActivX Biosciences
Dr. Nancy S. Mills, Trinity University
Dr. Jeanne E. Pemberton, University of Arizona, Chair 2000-02
Dr. William F. Polik, Hope College, Vice Chair 2005, Chair 2006-08
Dr. Barbara A. Sawrey, University of California, San Diego
Dr. Maria da Graca H. Vicente, Louisiana State University
Notes
UNM's Mission

The University will engage students, faculty, and staff in its comprehensive educational, research, and service programs.

- UNM will provide students the values, habits of mind, knowledge, and skills that they need to be enlightened citizens, to contribute to the state and national economies, and to lead satisfying lives.
- Faculty, staff, and students create, apply, and disseminate new knowledge and creative works; they provide services that enhance New Mexicans’ quality of life and promote economic development; and they advance our understanding of the world, its peoples, and cultures.
- Building on its educational, research, and creative resources, the University provides services directly to the City and State, including health care, social services, policy studies, commercialization of inventions, and cultural events.
BS/BA Requirements.

Degrees offered:

- Bachelor of Arts (B.A.)
- Bachelor of Science (B.S.)
- Shared credit BS/MS (4+1) Option

Please see the Chemistry Roadmaps

University requirement

- Admitted to a degree-granting college
- Earned 128 hours minimum
- Completion of ENGL 1120 (or equivalent)
- Cumulative GPA of 2.0 or higher
- Completion of Core Curriculum
  - All courses being used toward the Core must be completed with a grade of “C” or higher; grades of “C-” or lower will NOT count toward completion of core requirements.
  - Core courses

College requirement

- 96 hours of coursework taken from departments housed in A&S
- 42 hours upper division coursework
- 128 earned hours minimum in course work acceptable to A&S
  - Excludes remedial coursework
  - Excludes coursework in pre-professional and/or technical programs
  - Includes up to 4 hours of PENP or performance music or dance

Degree requirements are based off of the catalog year that students enter the University. Students are allowed to choose from any catalog after their first academic year.

Departmental requirement

B.A. degree

The B.A. degree in Chemistry is designed to provide basic training in chemistry for flexible career pursuits such as teaching and health professional.

- **Required Chemistry courses:**
  - 1215/1215L (4) Gen Chem I
  - 1225/1225L (4) Gen Chem II
  - 2310C (4) Quantitative Analysis
• 301/303L (4) Organic Chem I
• 302/304L (4) Organic Chem II
• 315 (4) Intro Physical Chem

• **Required non-chemistry courses:**
  o Physics 1230/1230L & 1240/1240L
  o Math 1512 and 1522

• **Elective courses (minimum 7 hours):**
  o 421 Biological Chem
  o 425 Biological Pathways
  o 431 Advanced Inorganic Chem
  o 453L Analytical Instrumentation
  o 457 Environmental Chem
  o 471 Topics
  o 495-496 (no more than 2 credit hours)

• **A minor is required.**
• **These courses are offered during specific semester:**
  o **Fall only:** 431
  o **Spring only:** 453L

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**B.S. degree**

The B.S. degree in Chemistry is designed to prepare students with research experience for pursuing more advanced training in graduate programs or entering the workforce.

Departmental B.S. Requirements:

• **Required Chemistry courses:**
  o 1215/1215L (4) Gen Chem I
  o 1225/1225L (4) Gen Chem II
  o 2310C (4) Quantitative Analysis
  o 301/303L (4) Organic Chem I
  o 302/304L (4) Organic Chem II
  o 311 (3) Physical Chem
  o 312 (3) Physical Chem
  o 411L (3) Lab Methods in Physical Chemistry
  o 431 (3) Advanced Inorganic
  o 453L (4) Analytical Instrumentation

• **Required non-chemistry courses:**
  o Physics 1310/1310L & 1320/1320L
  o Math 1512, 1522, 2530 & one course from 311-316

• **Elective courses (minimum 7 hours):**
  o 325-498 (up to 3 credits of 495-498 or 2 credits of 495-498 and 1 credit of 325-326)
  o At least 3 credit hours must be for a laboratory course

• **These courses are offered during specific semester:**
- **Fall only**: 311, 411L, 431
- **Spring only**: 312, 453L

**Optional Distributed Minor**

- Completion of the B.S. requirements
- Additional Math Course Math 311, 314, or 316
- English 2210 (219) Technical Writing

**ACS Certification**

- Completion of the B.S. requirements
- Must include Chem 421 for biochemistry requirement
- 3 research credit hours (can also count towards electives) or Chem 432L
MS requirements.

Check Sheet for Program of Study Form (Plan I--Thesis Masters)

24 total hours including the following:

- 15 hours of graded (A, B, …) Chemistry coursework
- 6 of the 15 hours of graded (A, B, …) Chemistry coursework must be 500 level or above
- 2 – 4 hours of CHEM 625 (Divisional Seminar)
- Up to 4 hours of CHEM 650

Six hours of Thesis (599) credit

Check Sheet for Program of Study Form (Plan III--Coursework Masters)

32 total hours including the following:

- 18 hours of graded (A, B, …) Chemistry coursework
- 12 of the 18 hours of graded (A, B, …) Chemistry coursework must be 500 level or above
- 2 – 4 hours of CHEM 625 (Divisional Seminar)
PhD Requirements

Check Sheet for Application for Candidacy

48 total hours including the following:

- 18 hours of graded (A, B, ...) Chemistry coursework must be 500 level or above
- 3 – 6 hours of CHEM 625 (Divisional Seminar)
- Enough hours of graduate credit (CHEM 650 or 623) to meet the total of 48 hours (not more than 24 hours of CHEM 650)

18 hours Dissertation (699)
University of New Mexico

Department of Chemistry & Chemical Biology

Graduate Handbook

Fall 2017
INTRODUCTION:

This handbook describes the graduate program and degree requirements for the Department of Chemistry & Chemical Biology (CCB) at The University of New Mexico (UNM). University requirements may be found in the current UNM Catalog at: http://catalog.unm.edu/catalogs/2014-2015/graduate-program.html. Students are responsible for knowing and understanding these requirements and for making satisfactory progress toward fulfilling them. This document outlines the specific and additional requirements for CCB. Questions about requirements should be directed to the Graduate Coordinator and/or the chair of the Graduate Studies Committee.

The CCB graduate program is overseen by the Graduate Studies Committee (GSC), a standing committee of tenure-track faculty appointed by the department chair. The GSC is responsible for advising first year students, overseeing the graduate program, and evaluating graduate student performance throughout their tenure in the CCB graduate program.

The CCB graduate program offers a Doctor of Philosophy (PhD) and a Master of Science (MS; with or without a thesis) degree. The PhD is a research-oriented degree that prepares students for scientific careers as independent investigators and group leaders in academia, research institutes, national laboratories and industry. The thesis MS is a research degree of lesser scope and independence, intended to prepare students for scientific careers including research; the non-thesis MS is intended as a preparation for professional chemists who will not conduct research.

GENERAL POLICIES:

All students are expected to enroll full time each semester. No more than 11 credits the first semester of graduate school and up to 12 hours for each fall and spring semester thereafter. The Graduate Studies Committee recommends which courses students will take during their first year. Starting the student's second year, the student will meet with their Research Director for which courses to take to support their graduate research.

After completing formal coursework requirements, students must enroll in CHEM 650 (Research/Readings) until they are advanced to candidacy. After the student advances to candidacy, they must enroll in CHEM 699 (Dissertation). If a student is working on a master's program with thesis, they must register for CHEM 599 (Master's Thesis) after completing their formal coursework requirements. The student should consult his/her Research Adviser or the Graduate Coordinator before registering for any courses. Students should not enroll in coursework during summer sessions unless the student will be graduating during the summer session. In this case, the student must enroll in at least 3 credit hours of CHEM 699 for Dissertation or 1 credit hour of 599 for Master's Thesis or 2 credits of CHEM 650 if they are doing a coursework Master's.

All CCB graduate students are expected to maintain the highest standards of honesty and integrity in academic and professional matters. Academic ethics violations such as cheating or plagiarism can carry severe penalties, up to and including dismissal from the graduate program. Students are expected to earn a “B” or better (not B-) in CCB courses. Students are also required to maintain a cumulative GPA of 3.0 or higher during their graduate studies at UNM. Failure to maintain a cumulative minimum 3.0 GPA or to make adequate annual progress in courses and/or research may lead to dismissal, movement from the PhD to MS track and/or termination of financial support. Graduate students on teaching assistantship (TA-ship) are also expected to receive satisfactory evaluations from the students enrolled in the course and from the faculty member in charge of the course. All students are responsible for knowing and complying with UNM and departmental academic regulations. Ignorance of a rule or policy will not be accepted as an excuse for non-compliance.

STUDENT ASSISTANTSHIPS:

A graduate assistantship is a financial award to a graduate student for part-time work in teaching or research while pursuing study toward an advanced degree. In CCB, both teaching assistantships (TA-ships) and research assistantships (RA-ships) are available. Graduate assistantships typically obligate the holder to 20 hours of work per week at the discretion of the instructor in charge (TA-ship) or research director (RA-ship). Both RA and TA
contracts allow a tuition waiver of up to 12 credit hours for each fall and spring semester. Tuition will not be paid in the summer unless the student plans on graduating during the summer semester.

Duties of teaching assistants (TA’s) may include but are not limited to preparation of experiments, supervision of lab sections, holding recitation sections and office hours and grading. TA’s report to the instructor in charge of their assigned course/s and obtain specific assignments from that instructor.

TA’s are expected to work the week before the fall and spring semester classes preparing for the upcoming semester. TA’s are also expected to be on campus during the week of final exams. Exceptions to this policy require written approval of the instructor in charge and violations may lead to serious penalties. All teaching assistants must enroll in CHEM 500, Scientific Teaching in Chemistry their first semester as a TA.

The performance of all TA’s will be reviewed every semester by the Teaching Performance Committee. The Teaching Performance Committee consists of four members: a representative of the Graduate Recruitment and Selection Committee, a representative of the Graduate Studies Committee, the Undergraduate Laboratory Supervisor and the instructor in charge. This Committee is responsible for reviewing Teaching Assistant performance and has the power to change Teaching Assistant status. Consistently poor or irresponsible performance by Teaching Assistants may result in the student being placed on probationary status, or in extreme cases, losing their financial aid altogether. If TA performance is deemed unsatisfactory, students will be required to enroll in CHEM 500 an additional semester constituting a probationary period.

Research assistants (RA’s) participate in research work that is relevant to the assistant’s thesis, dissertation or other requirement for a graduate degree. The RA is supervised by an adviser, who both directs the research and evaluates the RA’s performance. Typically, students are expected to carry out research during the entire year including the summer. RA’s should discuss and coordinate plans for vacation or leave with their research advisers.

**LIMITATIONS ON FINANCIAL AID:**

The Department of Chemistry & Chemical Biology restricts departmental financial aid in the form of Research and Teaching Assistantships to a maximum of six calendar years from the date of entrance. At the end of the fifth year, the student’s overall progress will be evaluated to determine their eligibility for a sixth year of support.

If, in the opinion of a student’s adviser and the GSC, a student shows little promise of completing the degree program, the Department will notify the student and the Graduate School in writing that the student is suspended from further work in the program.

**DOCTOR OF PHILOSOPHY (PhD) PROGRAM:**

The PhD program requires coursework, a written and oral candidacy exam, defense of a dissertation proposal, and the successful writing and defense of a dissertation. Completion should require 4-5 years of full-time study, assuming normal progress. In general, first year activities focus on teaching, coursework and selecting an adviser, while the second year focuses on completing coursework, passing the candidacy exam and proposing and initiating dissertation research. The final 2-3 years focus almost exclusively on research and writing and defending the dissertation.

First year PhD students typically take 2-3 graded 5xx level classes per term, take any required introductory classes, attend departmental colloquium and teach undergraduate laboratory sections. Students are expected to investigate the research programs of departmental faculty, and choose a laboratory in which to carry out their dissertation research. In consultation with their Research Advisers, students choose the members of their Committee on Studies (COS) before the end of the spring term. Most first-year students are on TA-ship during the academic year, and assessment of student progress by the GSC relies primarily on coursework performance and evaluation of teaching performance.
Second year PhD students typically complete their coursework requirement, participate in graduate seminars and research group meetings, and prepare for and take their candidacy exam and dissertation proposal defense. In addition, these students begin to accrue a collection of experimental techniques and protocols necessary to carry out successful dissertation research. Student progress is evaluated by the COS, which will monitor student progress toward synthesizing background material and experimental approaches relevant to the dissertation project, and will provide the student with constructive feedback.

Students who have passed the written and oral candidacy exam are considered admitted to candidacy for the PhD, and are expected to concentrate their efforts on their dissertation research. After admission to candidacy students have a maximum of five years to defend and submit their dissertations. Progress toward this goal is evaluated annually by the adviser and COS. NOTE: Financial support from the department (TA or RA-ship) is guaranteed only for students in good standing (making good progress) for five years from the date the student entered the department.

**PhD COURSEWORK:**

48 hours of graduate coursework including the following:

- 18 hours of graded (A, B, …) coursework must be 500 level or above including at least 12 hours in Chemistry courses. Colloquia, seminars and teacher training courses do not count toward this requirement
- At least 4 hours of graduate seminar CHEM 625 (Divisional Seminar)
- At least 4 hours of departmental colloquium CHEM 623
- Enough hours of graduate credit (CHEM 650 or 623) to meet the total of 48 hours (not more than 24 hours of CHEM 650)

18 hours Dissertation (699)

**SELECTING A RESEARCH ADVISOR:**

All PhD students must have an assigned research adviser by January 15 of the first spring semester to ensure adequate research progress and funding during the summer. The selection of an adviser is based on mutual preference (student and faculty), the availability of funding and faculty needs. Two meetings from the graduate recruit committee and the GSC are scheduled to discuss student distribution and assignment. Official assignment of a student to an adviser requires signatures of the student, the adviser and the chair of the GSC. Information on potential advisers and their research is available from the CCB website, formal research presentations, and individual meetings with faculty.

**TIMETABLE:**

By November 30 of the fall semester, first year students should have met with at least three different potential advisers to discuss research; each student must submit a ranked list of three potential research advisers to the GSC. The CCB faculty will use these lists, their own preferences, and information on RA support and faculty needs to match students with suitable advisers.

By December 10, the GSC will inform each student of his or her adviser match. Any requests for a different adviser must be made to the GSC by December 17 of the fall semester. By the 1st day of spring semester, the adviser assignment form, signed by student and the adviser, must be submitted to the GSC for approval by the GSC chair.

**NEW RESEARCH DIRECTOR:**
In some cases (illness, faculty leaving the department, etc.) a student must select a new research adviser. This selection process should be undertaken under the direction of the GSC chair, and requires the mutual agreement of the student, the new adviser and the chair. Once a new adviser has been selected, the student should notify the Graduate Coordinator and, with the advice of the new adviser, select a new COS by the end of the semester. The new COS will then decide what portion of the student’s completed work can be used towards his or her PhD dissertation. The COS will examine the student’s progress and assess whether the student has the appropriate skills and background to undertake the newly selected research program. In the situation where a student cannot find another adviser, the student must leave the department, as there will be impossible to meet all requirements for the PhD degree.

COMMITTEE ON STUDIES:

Following the selection of a Research Adviser, a PhD student must select a Committee on Studies (COS). The composition of this committee is outlined in the University of New Mexico catalog under “Graduate Program Composition of the Dissertation Committee.” The COS has a minimum of four members, including at least one external member who does not have a primary appointment in CCB. The COS is chaired by the student’s adviser. Students are expected to write their annual research progress report and meet yearly with their COS to review progress on research problems, plans, expectation, and appropriate degree requirements. Depending on the field of research, the COS may require the student to exhibit competence in additional areas such as mathematics, physics, computer programming, electronics, etc.

SEMINARS:

The Department of Chemistry & Chemical Biology has a two-part seminar program:

1. **Divisional Seminars** dealing with material in each of the three areas of chemistry: Biological Chemistry/Chemical Biology/Medicinal Chemistry; Physical Chemistry/Energy/Materials, and Catalysis/Synthesis, are formalized in CHEM 625 (Chemistry Seminar). With the exception of their first fall semester, students must register for a section that deals with their area of concentration every semester until the end of the 3rd year. During students’ second and later semesters, they must register for a divisional seminar. It is expected that all graduate students participate in the division seminar program while they are at UNM. The divisional seminar is charged and organized by a participating faculty. Grades are assigned by participating faculty in each division as either credit (CR) or no credit (NC).

   The seminar format is determined by each division and may include journal clubs and student presentations. For a PhD degree, the student must present two research seminars in the 2nd and/or 3rd years with at least score of pass as one of the requirements toward his/her PhD degree. For a MS degree, one presentation must be given in the 2nd year. The presentation topic should not be directly related to his/her research. The presentation materials should be from current literature but excluding review articles. The presentation topic and abstract must be sent to Faculty and students at least 3 days before the seminar date. The Faculty will evaluate the presentation with a score of merit, pass or no pass. The failure of the presentations requires redoing it.

   Part-time students who work at Los Alamos National Laboratory may register for CHEM 625 if they make arrangements to attend weekly seminar at LANL and give their presentation at a Divisional Seminar (CHEM 625) at UNM. The students’ Committee on Studies must approve these arrangements at the beginning of the semester. The LANL member of this committee reports on students’ attendance at LANL seminars to the faculty member responsible for the corresponding CHEM 625 section that grades the students accordingly.

2. **Departmental Seminars** consist of lectures given by invited speakers. All graduate students must register for CHEM 623 (department colloquium) for at least 4 semesters. After fours semesters, attendance is required but registration is not. Missing more than two Departmental Seminars in one
semester will result in a NC being given. Students will not read papers or use PDAs, computers, etc., during seminar and those caught doing so will have materials confiscated.

**DISSERTATION RESEARCH PROPOSAL:**

Defense of the dissertation research proposal must be completed by the last day of the student’s fourth semester in the program (not including summer), unless an extension is approved by the COS and the Graduate Studies Committee. If a student fails the defense, they may be allowed one additional attempt pending approval by the COS. This attempt must be completed no later than the end of the fifth semester. The COS may require students to repeat any or all parts of the proposal and defense. A second failure on any part of the requirement will prevent the student from continuing in the PhD program.

All students must submit a signed Announcement of Exam form to the Chemistry & Chemical Biology Department Advisement Coordinator at least two weeks prior to the scheduled RP. See the Advisement Coordinator for a copy of this form.

**DISSERTATION RESEARCH PROPOSAL RULES AND GUIDELINES:**

The dissertation research proposal represents a thoroughly documented summary of the research that the student expects to perform prior to writing their Dissertation. The written version of the proposal should consist of a concise narrative describing the intended doctoral research project. The written proposal should be fully documented, with appropriate references to the primary chemical literature. It should state clearly and concisely the objective(s) of the research and provide sufficient background to convey the rationale for undertaking the research. Particular emphasis should be on the motivation and background for the work as well as alternative approaches for carrying out the proposed work. Finally, key aspects of the planned method should be described briefly and their viability documented and justified. The fully referenced proposal with abstract should be distributed to the students’ COS two weeks prior to the defense.

**RESEARCH PROPOSAL GUIDELINES:**

These are only guidelines - it will ultimately be between the student and the COS how the RP will be written and orally presented.

- Abstract - approximately 400 words which states your objectives and goals
- Introduction - approximately 1½ - 2 pages of a brief literature overview
- Statement of Research Problem - not more than ½ of a page long
- Statement of Goals and Objectives - not more than ½ of a page long
- Research Plan - approximately 3 - 4 pages
- Conclusion - approximately ½ of a page long
- References

The total length should not exceed 10 pages, including references, figures, schemes, and equations. The style should be 12 pt. Times or Times Roman font, single spaced with 1” margins all around. A cover page should be included which has the title of the RP, the student’s name, and the names of the committee members listed.

**ORAL PRESENTATION GUIDELINES:**

The organization of the oral RP should be similar to the written presentation, and should include the same subheadings. The oral presentation should be approximately 25-30 minutes in length, excluding a question period.

**DEFENSE OF DISSERTATION:**

Candidates for a PhD degree are required to perform significant and independent research that culminates in the preparation and defense of a Dissertation. Each student’s research is conducted under the supervision and direction of their adviser and COS. Oral defense of the Dissertation begins with a public seminar in which
students present and summarize their research and the student answers questions from the audience (moderated by the adviser). This public seminar is followed by a private oral examination by the student’s adviser and COS.

Students completing a PhD must submit a Dissertation in approved UNM format. Students should consult the graduate bulletin and/or obtain detailed format guidelines from the Office of Graduate Studies. Electronic copies of the finished and approved Dissertation must be submitted to the graduate school, the CCB Advisement Coordinator and members of the examining committee.

Continuous enrollment in Dissertation (CHEM 699) hours is required in subsequent semesters (exclusive of summer) after initial enrollment in CHEM 699 until the Dissertation is accepted by the Dean of Graduate Studies. This rule applies whether or not the candidate is enrolled for other credit hours. Candidates who fail to register for CHEM 699 or CHEM 599 in any semester must pay tuition and late fees for each missed semester and petition the Office of Graduate Studies for reinstatement. In extraordinary circumstances, the Dean of Graduate Studies may waive the requirement for continuous enrollment upon presentation of a written request from the Dissertation Director and the graduate unit. Doctoral candidates must be enrolled for a minimum of 3 hours of CHEM 699 during the semester in which they complete their degree requirements, including the summer session.

Students must submit a signed Announcement of Exam form at least two weeks prior to their scheduled Dissertation Defense, and submit a signed Report of Exam Form immediately following their defense. A public notice of the Dissertation Exam defense should be made by posting announcements within the Department at least one week ahead of the scheduled defense. All students must also submit a signed Report of Dissertation Form for each committee member (one form for each member). These forms should be submitted to the Advisement Coordinator.

MASTER OF SCIENCE PROGRAM:

The MS program emphasizes coursework, and may require (Plan I) the successful writing and defense of a thesis. Completion should require 2 years of full-time study, assuming normal progress. MS students may follow a path similar to first year PhD students, typically taking 2-3 graded 5xx level classes per term. Additionally, they will take any required introductory classes, attend departmental colloquium and teach undergraduate laboratory sections. Students are expected to investigate the research programs of departmental faculty, and choose a laboratory in which to carry out their thesis research (if Plan I). In consultation with their Research Advisers, students choose the members of their Committee on Studies (COS) before the end of the spring term. Most first-year students are on TA-ship during the academic year, and assessment of student progress by the GSC relies primarily on coursework performance and evaluation of teaching performance.

The MS program has two distinct tracks--Plan I (Master’s Thesis) and Plan II (Coursework Master’s). The requirements for completion are listed below:

**PLAN I - MASTER’S THESIS:**

24 total hours including the following:

- 15 hours of graded (A, B…) coursework
- 6 of the 15 credit hours must be at the 500 level or above

- Required core courses:
  - CHEM 511
  - CHEM 521
  - CHEM 536
  - CHEM 501

- 2 - 4 hours of CHEM 625 (Divisional Seminar)
6 hours Thesis (599)

PLAN II - COURSEWORK MASTERS:

30 total hours including the following:

- 18 hours of graded (A, B…) coursework
- 12 of the 18 credit hours must be at the 500 level or above

- Required core courses:
  - CHEM 511
  - CHEM 521
  - CHEM 536
  - CHEM 501

- 2 - 4 hours of CHEM 625 (Divisional Seminar)
Expanded Course-based Undergraduate Research Experience (ECURE) is a UNM-NSF Initiative to study the benefit of incorporating different degrees of research experience in undergraduate courses in student’s learning. CHEM 1215L is an example of the implementation of ECURE in STEM General Education Course. Since the implementation in the Fall of 2018, ECURE has expanded into CHEM 1225L and is included in multiple formats from face-to-face to fully online.
Who are taking CHEM 1215L?

- STEM students as the first science lab
- Students who are also taking the general chemistry lecture
- More than 28 majors require this course
- Freshman students who are curious about sciences
- Best candidates for early engagement in UGR
- Annual enrollment of 1200 students
This slide places the CHEM 1215L in the ECURE framework. The ECURE framework has been developed by AAGE Faculty Fellows in 2018-2019, which consists of the classification of course activities of different research elements common to different disciplines. Most of the activities of this course fall in the category of partial CURE.
Learning Goals

Students can

1. apply background knowledge to experimental work
2. plan & prepare evidence
3. collaborate & communicate scientific ideas
4. model the practices of a scientist
5. learn from failure & iterations
6. be aware of ethical responsibilities working in a lab

The Learning goals of this course match the framework of ECURE and are explained to students in the course orientation. For most freshman students, these goals are new to them and have not experienced from high school chemistry lab.
Students are given orientation on the first week. In the orientation, students are explained and demonstrated what they will be expected to do for each activity. This step is crucial for the success of ECURE. We require students to pass an orientation test in order to proceed in the real experiments.
For each experiment, students first are briefed with the lab scenario and background reading materials. Their understanding will be evaluated with a quiz. This is considered as “literature search” in a real-world research project. Because students are not expected to be able to carry out a real literature search at the freshman level, background reading materials are given to them instead. Therefore, we rate this activity only at preparatory level.
After students completed the background reading, they come to the lab for the first time. The goal of the first lab is to develop the experimental procedure. At this point, they only have the picture of lab question and the background information about the question. They do not have the content of the experiment yet. We expect students to form concrete ideas of what need to be accomplish in the lab in order to collect sufficient evidence for answering the lab question. We like students to generate the experiment through group discussions. Depending on the format of the lab, we employ different discussion tools. In the in-person lab, we organize students into small (2-3 students) groups. In the online format, we use zoom break-out rooms or group discussion forum.
In the second lab of each experiment, our goal is for students to collect useful data as the evidence for their conclusion of the lab question. They will follow their own experimental procedure previously design to carry out the experiment and collect data. They will learn from mistakes during the data collection, solving un-expected problems, trouble-shooting obstacles, and experiencing iterations. They will have chances to prefect their lab techniques during this lab.
We also require students to practice one of the most important research skills – making scientific arguments. The process of making arguments require students to use most of the higher levels of cognitions and to practice multimodal communication skills about scientific ideas. In this course, we introduce students to the Question-Claim-Evidence-Justification (QCEJ) model of making scientific argument and help them be proficient by scaffolding approach. We ask students to practice one element of the QCEJ model at a time (such as claim for experiment 1, evidence for experiment 2, etc.) to avoid overloading of their working memory. The picture in the slide shows students practicing making scientific arguments in a small group.
Communication is another important research element in ECURE. We ask every student to prepare and give presentations in the lab for all formats. The discussion is also practiced for design and data collection. The report writing is also required for students. Our goal is for students to be equipped with basic skill of communicating scientific ideas verbally and in writing under different setting.
Ethical awareness is another important aspect of research which is often ignored in the formal educationally setting. We use a software to check every report against a large on-campus database. We have a very strict and educational course policy for plagiarism. There is a very detailed description of what should and should not do to avoid plagiarism. Since the implementation of ECURE, we have corrected many misconceptions of students regrading plagiarism.
For chemistry lab, safety is as important as the experiment itself. We not only focus on the enforcement of safety rules, but also fostering of safety awareness and prevention. During every experimental design, we require students to have safety discussion and learn how to disseminate the information acquired from SDS. We also include the safety in our assessments of student’s performance.
We have a variety of assessment tools for student's performance from the course. The lab skills are evaluated by two separate tests. The skill assessments are direct observation about each student's ability to carry out the lab techniques. The practical exam is a comprehensive test requiring students to combine hands-on activities and their comprehension about the chemical principles in their answers. For online format, we use zoom interviews for the assessments.
The concept inventory test was written in 2016 to be used to calculate the student’s laboratory learning gains each semester. This test is given as pre- (during the first week) and post-test (during the last week). The learning gains have been used to study the effectiveness of courses from semester to semester.

**Laboratory Concept Inventory**

1. Laboratory Safety Awareness
2. Experimental Design
3. Key hard lab skills (making solutions, measurements, etc.)
4. Key soft lab skills (tables, figures, hypothesis, etc.)
5. Scientific arguments
6. Deductive & inductive reasoning
7. Use of statistics
Assessing Student Learning from CURE

Pre-test and Post-test for Lab Concept learning gains

Different performance measures were used for Lab Skills
- Skill Assessments
- Final practical exams

This slide explains the three tools we used for assessments for ECURE.
This is a result of comparing student’s skills between those who had ECURE to those had no ECURE. For 1215L, students from 2018 had no ECURE, but from 2019 they had ECURE. The skill assessments showed significant difference between the two semesters. For 1225L, both 2018 and 2019 had no ECURE and their skill assessments showed no difference. This is the first evidence of the difference ECURE will make for student's learning.
From the Lab Concept Inventory test result, we found students with two semesters’ ECURE (ECURE group) had the highest mean learning gains. The students without any ECURE (non-ECURE group) had the lowest mean learning gains. The students who had one semester’s ECURE had the mean learning gains higher than the non-ECURE group, but lower than the ECURE group. This is another important evidence for the effectiveness of ECURE on student’s learning.
Comparing the Means

![Graph showing comparing the means of different groups.]

This slide supports the same conclusion as from the previous slide regarding the learning gains from pre- and post-concept inventory tests.
This slide summarizes the differences between the face-to-face format and online format of ECURE in CHEM 1215L in terms of the ECURE framework. The CHEM 1225L has also been converted into ECURE in the spring semester of 2021.

<table>
<thead>
<tr>
<th>Research Elements</th>
<th>Face-to-Face format</th>
<th>Online Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethic Awareness</td>
<td>Scientific Arguments, Reports, <strong>Safety practices</strong></td>
<td>Scientific Arguments, Reports, <strong>Safety awareness</strong></td>
</tr>
<tr>
<td>Gathering Background</td>
<td>Background reading, Quizzes</td>
<td>Background reading, Quizzes</td>
</tr>
<tr>
<td>Preparing Evidence</td>
<td>Lab design, Data collection, Scientific Arguments, Reports, Quizzes</td>
<td>Lab design, Data collection, Scientific Arguments, Reports, Quizzes</td>
</tr>
<tr>
<td>Communication/</td>
<td>Reports, Presentation, Class &amp; small group</td>
<td>Reports, Presentation, Class &amp; small group <strong>Discussion Forums</strong></td>
</tr>
<tr>
<td>Collaboration</td>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>Real-World Practices</td>
<td><strong>Lab practices, Safety practices, Scientific Arguments</strong></td>
<td>Scientific Arguments, <strong>Reports, and Discussion Forums</strong></td>
</tr>
<tr>
<td>Freedom to Discover</td>
<td>Lab Design, <strong>Lab Practices</strong>, Scientific Arguments</td>
<td>Lab Design, Scientific Arguments</td>
</tr>
<tr>
<td>Failure &amp; Iteration</td>
<td><strong>Lab Practices</strong>, Reports</td>
<td>Reports, <strong>Discussion Forums</strong></td>
</tr>
<tr>
<td>Outcome Novelty</td>
<td>Scientific Arguments, Reports,</td>
<td>Scientific Arguments, Reports,</td>
</tr>
</tbody>
</table>
This slide compares the face-to-face format with the online format of ECURE for CHEM 1215L under the UNM-ECURE framework. The online format has its limitation for the degree of ECURE we can deliver to students. The future work will focus on the possibility of removing the limitation of online format so that the same degree of ECURE can be hosted in the online format. Evidence will also be collected to compare the effectiveness of online format of ECURE to that of the face-to-face format. We will also investigate developing a full scale of ECURE in the future.
Academic Program
Plan for Assessment of Student Learning Outcomes
The University of New Mexico

A. College, Department and Date

1. College: Arts and Sciences: Main Campus
2. Department: Chemistry and Chemical Biology
3. Date: 10/6/2020

B. Academic Program of Study
B.A. Chemistry

C. Contact Person(s) for the Assessment Plan
K Joseph Ho, khoj@unm.edu

D. Broad Program Goals & Measurable Student Learning Outcomes

The Student Learning Outcomes have been streamlined as listed below:

1. **Content Mastery:** Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry
   a. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises. *(NM HED Area III: 2)*
   b. Be able to employ critical thinking to solve problems using multiple layers of data analysis *(NM HED Area III: 2, 4)*

2. **Communication Skills:** Convincingly present scientific data and arguments in an oral and written format
   a. Organize and represent experimental data using appropriate methods (spreadsheets, etc) *(NM HED Area III: 1, 2, 4)*
   b. Write coherent scientific reports *(NM HED Area III: 3)*

3. **Professional Development:** Be prepared for entry into professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.
   a. Have a working knowledge of basic laboratory safety *(NM HED Area III: 5)*
   b. Demonstrate scientific literacy *(NM HED Area III: 3, 5)*
   c. Have general skills to work in small groups to accomplish scientific projects *(NM HED Area III: 5)*
E. **Assessment of Student Learning Three-Year Plan**

All programs are expected to measure some outcomes annually and to measure all priority program outcomes at least once over two consecutive three-year review cycles. Describe below the plan for the next three years of assessment of program-level student learning outcomes.

**Plan Timeline:**

<table>
<thead>
<tr>
<th>Goal/SLO</th>
<th>2019-2020: Courses to be</th>
<th>2020-2021: Courses to be</th>
<th>2021-2022: Courses to be</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Content Mastery: Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry</strong></td>
<td>A1. CHEM 302 Exit interview</td>
<td>A2. CHEM 301 Exit interview</td>
<td>A1. Exit interview CHEM 315</td>
</tr>
<tr>
<td>1. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises. <em>(NM HED Area III: 2)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Be able to employ critical thinking to solve problems using multiple layers of data analysis <em>(NM HED Area III: 2, 4)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Organize and represent experimental data using appropriate methods (spreadsheets, etc) <em>(NM HED Area III: 1, 2, 4)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Write coherent scientific reports <em>(NM HED Area III: 3)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. Professional Development: Be prepared for entry into professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.</strong></td>
<td>C1. CHEM 1225L Exit interview</td>
<td>C2. CHEM 452 Exit interview</td>
<td>C3. CHEM 304L Exit interview</td>
</tr>
<tr>
<td>1. Have a working knowledge of basic laboratory safety <em>(NM HED Area III: 5)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Demonstrate scientific literacy <em>(NM HED Area III: 3, 5)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Have general skills to work in small groups to accomplish scientific projects <em>(NM HED Area III: 5)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. **Student Learning Outcomes**

   Relationship to UNM Student Learning Goals (insert the program SLOs and check all that apply):

<table>
<thead>
<tr>
<th>Student Learning Outcomes (SLOs)</th>
<th>Program Goal #</th>
<th>UNM Student Learning Goals</th>
<th>Assessment Measures</th>
<th>Performance Benchmark</th>
<th>Student Population(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For each row in the table, provide a SLO. If needed, add more rows. A SLO may be targeted by or aligned with more than one program goal. If a program awards more than one degree (i.e., B.S., M.A. etc.), the SLOs for graduate and undergraduate must be different. Graduate degree SLOs must be different (Master ≠ Doctorate). For additional guidance on SLOs, click here.</strong></td>
<td>Please list the Program Goal(s) that the under. Use the numbering system (1,2,3..) assign</td>
<td>Check as appropriate: K=Knowledge; S=Skills; R=Responsibility</td>
<td>Provide a description of the assessment instrument used to measure the SLO. For additional guidance on assessment measures, click here.</td>
<td>What is the program’s benchmark (quantitative goal/criteria of success for each given assessment measure)? State the program’s “criteria for success” or performance benchmark target for successfully meeting the SLO (i.e., At least 70% of the students will pass the assessment with a score of 70 or</td>
<td>All students would be included in the assessment of a service course without separating majors from the analysis with the assumption that a large sample can represent a small subset.</td>
</tr>
<tr>
<td>Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises.</td>
<td>1</td>
<td>✔</td>
<td>✔</td>
<td>Each SLO will be measured using samples of evidence of learning from courses: CHEM 315, 421/425, 253L, 124L, 452, 304L</td>
<td>The program’s assessment target is to have at least 60% of the students in the B.A. program to perform satisfactorily or better. Scoring rubrics will be used for some measures, designed by the faculty.</td>
</tr>
<tr>
<td>Be able to employ critical thinking to solve problems using multiple layers of data analysis</td>
<td>1</td>
<td>✔</td>
<td>✔</td>
<td>“”</td>
<td>“”</td>
</tr>
<tr>
<td>Organize and represent experimental data using appropriate methods (spreadsheets, etc)</td>
<td>2</td>
<td>✔</td>
<td>✔</td>
<td>“”</td>
<td>“”</td>
</tr>
<tr>
<td>Task Description</td>
<td>Level</td>
<td>Completed</td>
<td>Notes</td>
<td>Grade</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
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<td>----------</td>
</tr>
<tr>
<td>Write coherent scientific reports</td>
<td>2</td>
<td>✔ ✔ ✔</td>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>Have a working knowledge of basic laboratory safety</td>
<td>3</td>
<td>✔ ✔ ✔ ✔</td>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>Demonstrate scientific literacy</td>
<td>3</td>
<td>✔ ✔ ✔</td>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>Have general skills to work in small groups to accomplish scientific projects</td>
<td>3</td>
<td>✔ ✔ ✔ ✔</td>
<td>&quot;</td>
<td>&quot;</td>
<td></td>
</tr>
</tbody>
</table>
2. **How will learning outcomes be assessed?**
   A. **What:**
      1. Each SLO will be measured using samples of evidence of learning from courses listed in the table above.
      2. Each SLO measured will be a direct measure. If no major changes are made to the proposed program assessment plan then all measures over the next three years will be direct.
      3. The program’s assessment target is to have 60% of the students in the B.A. program to perform satisfactorily or better. Scoring rubrics will be used for some measures, designed by the faculty member who analyzes the data.
   B. **Who:**
      We will try to include all students in Chemistry B.A. degree program in the assessment.

3. **When will learning outcomes be assessed? When and in what forum will the results of the assessment be discussed?**

   Priority SLOs will be measured each spring and fall semester. The number of priority SLOs measured each year may vary between one and three SLOs. The results of the outcomes measured the previous fall will be discussed each August by an Assessment Committee. All department faculty will be notified via email and invited to the meeting no less than 3 weeks before the scheduled meeting.

4. **What is the unit’s process to analyze/interpret assessment data and use results to improve student learning?**

   1. The faculty collecting evidence during that academic year and the chair of the Assessment Committee will meet each August to analyze and interpret the assessment data. All faculty will be invited to participate in the meeting. Each faculty member who collected data will present how they carried out the assessment (the tools/techniques used), how they analyzed the data, and what will be done to improve student learning. Finally, plans will then be made for the following year so that only one or two SLOs are tested using one or more direct measures and the analysis is done by everyone attending the meeting using a “calibrated” rubric rather than just the faculty member who collected the data.
   2. 3. Recommendations will be compiled at the August meeting by the assessment committee chair and communicated in writing to the department chair with the signatures of all members of the assessment committee by September 1st each year. Copies of the document will be provided and discussed in the faculty meeting each September.
Academic Program
Plan for Assessment of Student Learning Outcomes
The University of New Mexico

A. **College, Department and Date**

1. College: Arts and Sciences: Main Campus
2. Department: Chemistry and Chemical Biology
3. Date: 10/6/20

B. **Academic Program of Study**
B.S. Chemistry

C. **Contact Person(s) for the Assessment Plan**
K. Joseph Ho, khoj@unm.edu

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1. **Content Mastery:** Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry
   a. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises. (**NM HED Area III: 2**)
   b. Be able to employ critical thinking to solve problems using multiple layers of data analysis (**NM HED Area III: 2, 4**)

2. **Laboratory Skills:** Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods
   a. Construct and test hypotheses (**NM HED Area III: 1,2**)
   b. Design experiments (**NM HED Area III: 2**)
   c. Use instrumentation to collect data (**NM HED Area III: 2**)
   d. Process data using a computer and use statistics to evaluate data (**NM HED Area III: 2, 4**)
   e. Have a working knowledge of basic chemical safety (**NM HED Area III: 5**)
   f. Interpret experimental results and draw conclusions (**NM HED Area III: 4, 5**)

3. **Communication Skills:** Convincingly present scientific data and arguments in an oral and written format
   a. Organize and represent experimental data using appropriate methods (spreadsheets, etc) (**NM HED Area III: 1, 2, 4**)
   b. Write coherent scientific reports (**NM HED Area III: 3**)
c. Present scientific ideas and arguments in a professional setting (NM HED Area III: 3)

4. Professional Development: Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.
   a. Demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry (NM HED Area III: 3, 5)
   b. Have general skills to work in small groups to accomplish scientific projects (NM HED Area III: 5)

E. Assessment of Student Learning Three-Year Plan
All programs are expected to measure some outcomes annually and to measure all priority program outcomes at least once over two consecutive three-year review cycles. Describe below the plan for the next three years of assessment of program-level student learning outcomes.

Plan Timeline:

<table>
<thead>
<tr>
<th>SLO</th>
<th>Year 19-20:</th>
<th>Year 20-21:</th>
<th>Year 21-22:</th>
</tr>
</thead>
</table>
| A. Content Mastery: Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry  
1. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises  
2. Be able to employ critical thinking to solve problems using multiple layers of data analysis | A1. 311/312 Exit interview | A2. CHEM 421/425 Exit interview | A1. 431 Exit interview |
| B. Lab Skills: Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods  
1. Construct and test hypotheses  
2. Design experiments  
3. Use instrumentation to collect data  
4. Process data using a computer and use statistics to evaluate data  
5. Have a working knowledge of basic chemical safety  
6. Interpret experimental results and draw conclusions | B4. CHEM 2230L  
B5. CHEM 432L Exit interview | B1. CHEM 1225L  
B6. CHEM 411L Exit interview | B2. CHEM 453L  
B3. CHEM 453L |
| C. Communication Skills: Convincingly present scientific data and arguments in an oral and written format | C3. CHEM 432L CHEM 453L Exit interview | C2. CHEM 2230L Exit interview | C1. CHEM 453L |
1. Organize and represent experimental data using appropriate methods (spreadsheets, etc)
2. Write coherent scientific reports
3. Present scientific ideas and arguments in a professional setting

<table>
<thead>
<tr>
<th>D. <strong>Professional Development:</strong> Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.</th>
<th>D1. CHEM 425/421 Exit interview</th>
<th>D2. CHEM 457 471 Exit interview</th>
<th>D1 Exit interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry</td>
<td></td>
<td></td>
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<tr>
<td>2. Have general skills to work in small groups to accomplish scientific projects</td>
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</table>
### 1. Student Learning Outcomes

Relationship to UNM Student Learning Goals (insert the program SLOs and check all that apply):

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<th>Student Learning Outcomes (SLOs)</th>
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<th>Assessment Measures</th>
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<th>Student Population(s)</th>
</tr>
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<tbody>
<tr>
<td>Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises.</td>
<td>1</td>
<td>✔</td>
<td>✔</td>
<td>Each SLO will be measured using samples of evidence of learning from courses required by the B.S. program.</td>
<td>The program’s assessment target is to have at least 60% of the students in the B.S. program to perform satisfactorily or better. Scoring rubrics will be used for some measures, designed by the faculty member who analyzes the data, and explained in the annual repgrts.</td>
</tr>
<tr>
<td>Be able to employ critical thinking to solve problems using multiple layers of data analysis</td>
<td>1</td>
<td>✔</td>
<td>✔</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Construct and test hypotheses</td>
<td>2</td>
<td>✔</td>
<td>✔</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Skill Description</td>
<td>Level</td>
<td>Completed</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>-------</td>
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<td>---</td>
</tr>
<tr>
<td>Design experiments</td>
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<td></td>
<td></td>
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<tr>
<td>Process data using a computer and use statistics to evaluate data</td>
<td>2</td>
<td>✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have a working knowledge of basic chemical safety</td>
<td>2</td>
<td>✔ ✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpret experimental results and draw conclusions</td>
<td>2</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Organize and represent experimental data using appropriate methods (spreadsheets, etc)</td>
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<td>✔ ✔</td>
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<td></td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate scientific literacy</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have general skills to work in small groups to accomplish scientific projects</td>
<td>4</td>
<td>✔ ✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. **How will learning outcomes be assessed?**
   
   **A. What:**
   
   1. Each SLO will be measured using samples of evidence of learning from courses listed in the table above.
   2. Each SLO measured will be a direct measure. If no major changes are made to the proposed program assessment plan then all measures over the next three years will be direct.
   3. The program’s assessment target is to have 60% of the students in the B.S. program to perform satisfactory or better. Scoring rubrics will be used for some measures, designed by the faculty member who analyzes the data.

   **B. Who:**
   
   We will try to include all students in Chemistry B.S. degree program in the assessment.

3. **When will learning outcomes be assessed? When and in what forum will the results of the assessment be discussed?**

   Priority SLOs will be measured each spring and fall semester. The number of priority SLOs measured each year may vary between one and three SLOs. The results of the outcomes measured the previous fall will be discussed each August by an Assessment Committee. All department faculty will be notified via email and invited to the meeting no less than 3 weeks before the scheduled meeting.

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   2. Recommendations will be compiled at the August meeting by the assessment committee chair and communicated in writing to the department chair with the signatures of all members of the assessment committee by September 1st each year. Copies of the document will be provided and discussed in the faculty meeting each September.
Periodic Report on Program Assessment of Student Learning

Academic year: **2013-2014**
Department/Program: *Chemistry and Chemical Biology*
Degree program(s): **BA**
Person(s) preparing report: *UG Committee*
Date submitted:

1. Describe the actions and/or plan revisions that were implemented during this reporting period in response to the previous period’s assessment results.

   Although some assessment data has been collected systematically each year according to the assessment plan, it was not compiled and analyzed as a whole owing to changes in department administration. As such the assessment results reported here provide a baseline for the future.

2. a) List the student learning outcomes (SLOs) that were assessed during this reporting period. If the assessment was performed in a way that is different from that described in your approved assessment plan, please describe the reasons for this and how the assessment was performed.

   1. Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry
      a. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises
   2. Be able to employ critical thinking and hypothesis-driven methods of scientific inquiry
      a. Solve problems using multiple layers of data analysis
   4. Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc.) or the chemical industry or government service.
      1. Apply general knowledge of chemical concepts to solve novel problems

Original plan (2009):
SLO 2a in Dr. Lisa Whalen’s CHEM 302 course. Professor Debi Evans will collect data related to SLO 1a in her CHEM 315. Depending on course enrollment numbers for chemistry majors, Dr. Joe Ho will use evidence from CHEM 253 to measure SLO 4a. Each will provide at least one direct measurement using graded material (exams, homework, or quizzes). The same SLOs and samples of learning will be gathered for the following two years unless the feedback obtained for the pilot study suggests major changes.

Changes to plan for 2013/2014 assessment cycle:

1. CHEM 253L was not covered due to the change of teaching assignments. The SLO 4a was therefore not assessed.
2. **CHEM 315**’s instructor was changed to Prof. David Keller.

b) Describe any developmental work that was done on your assessment plan, including developing new SLOs, creating new measurement methods, or amending your assessment plan.

*Exit survey:* The Department piloted an exit survey given to all graduating majors in Spring 2013 and Spring 2014. Primary areas of focus included strengths and weaknesses of the Department, significant courses and plans after graduation.

c) Describe the results of the assessment. What did you learn about strengths and weaknesses of student learning in your program?

**SLO 1a: CHEM 315**

Averages for the final exam from Chem 315 for semesters Fall 2011, Spring 2012, Fall 2012, Spring 2013 and Fall 2013 are shown Table 1 below. Chem 315 is one-semester, biologically oriented physical chemistry, required for all BA chemistry majors. Many of the students in the class are biochemistry majors, or biology majors with a second (usually BA) major in chemistry. Large sections of Chem 315 are devoted to chemical thermodynamics (and associated statistical-mechanical ideas) and chemical kinetics. The class is highly quantitative and math intensive, with a strong emphasis on converting qualitative ideas and information into quantitative calculations, mathematical expressions, and quantitative predictions. The final exam for Chem 315 is comprehensive over the material for the full semester, so both the score on the final and the overall class score are measures of student learning and retention of difficult physical/quantitative concepts, appropriate for SLO 1a, the ability to “Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry. Apply understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises”.

Both the final exam and overall class score show a general rise over the period in question. The class was taught by a single instructor over this period, using essentially the same pedagogical methodology in all semesters, so the scores are roughly comparable from semester to semester. These data are (of course) subject to considerable variation due to differences in difficulty between exams (both the final exam and the midterms, which contribute to the overall class score), and the trend is small. A likely explanation for the trend is the increased experience of the instructor over time, and small-but-steady improvements in presentation and materials. A large change in course content was implemented in Fall 2012 (a change in textbook, a large change in the emphasis put on biological applications of physical chemistry, a reduction in time spent on quantum mechanics and increased emphasis on thermodynamics and kinetics), and there is also a discernable jump in both scores at this point. To the extent that the jump is real (and not due to chance) a likely explanation is greater student interest and attention, because the new material is more closely aligned to their natural areas of interest.
Table 1

<table>
<thead>
<tr>
<th>Semester</th>
<th>Final Exam %</th>
<th>Overall Class %</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2011</td>
<td>66</td>
<td>76</td>
</tr>
<tr>
<td>Sp2012</td>
<td>60</td>
<td>73</td>
</tr>
<tr>
<td>F2012</td>
<td>71</td>
<td>75</td>
</tr>
<tr>
<td>Sp2013</td>
<td>74</td>
<td>75</td>
</tr>
<tr>
<td>F2013</td>
<td>67</td>
<td>82</td>
</tr>
</tbody>
</table>

Students in CHEM 315 are often highly motivated; many are aimed at careers in medical or professional areas with biological emphasis. They are also upperclassmen with experience how to study, learn difficult material, and take exams efficiently. The student group is also entirely in the STEM area, selected for ability to absorb difficult concepts and complex material. On the other hand, the material in CHEM 315 is more quantitative and mathematical than is often comfortable for this student group. Some review of “basic” math (logs, exponentials, complex units) and more advanced math (one-dimensional calculus, a little two and three dimensional calculus) is needed at the beginning of the semester. Some students struggle with algebra skills. All but the most mathematically adept students struggle with the process of turning a qualitative idea into a quantitative mathematical expression or calculation. Class materials, exam questions, and lecture materials are designed in part to address (and pre-empt, as much as possible) these systematic and repeated issues.

SLO 2a: CHEM 302

Questions aligned with course student learning outcomes “Interpret a $^1$H NMR spectrum and propose the structure of the compound that generates the spectrum; assign the proton environments,” and “Propose the 5-7 step synthesis of an organic compound from simple starting materials.”

Students were given questions on Exam I, II, III or IV that corresponded to the SLOs above. Their performance out of the maximum possible was recorded and the average for the class compared to the threshold for passing (70% = satisfactory). Chemistry BA and BS majors’ data were separated from the rest of the class for comparison. Data are included in the appendix.

In the 46-student Section 4, the 4 majors performed at the same level as the rest of the class for the entire semester on 6 of 7 questions. On the other 1, they performed slightly better (satisfactory versus less than satisfactory). In the 122-student Section 1, the 9 majors performed at the same level as the rest of the class on 5 of 7 questions. On the other 2, they performed slightly worse (less than satisfactory versus satisfactory and satisfactory versus good).
Student performance overall was outstanding to good on questions involving NMR interpretation. Performance on questions involving synthesis dropped to satisfactory to less than satisfactory, with less than satisfactory to good results on questions where students were given boxes to guide their thought process and did not require creative action on their part. This has always been and will continue to be an area to target for improvement in instruction.

Other results:

Exit surveys were given to students graduating with a BA or BSc in Chemistry in 2013 and 2014. A summary of their responses to questions relevant to program assessment is presented.

1. Plans on graduating: Out of the 14 students responding to the survey, 6 intended to continue to graduate school in chemistry or biochemistry. 3 were either attending or applying to medical school. 2 intended to work in industry. 1 each were going to pharmacy school or to do a master’s in public health. 1 aimed for industry or academia.

2. Most significant courses: A range of courses offered by the Department were mentioned. Several students mentioned Organic Chemistry, Physical Chemistry, Biological Chemistry and Organic Chemistry of Biological Pathways, but many courses were mentioned by at least one student: Chemistry of the Nanoscale, NMR, 411L, Quantitative Analysis, 431, 131L and 132L.

3. Strengths of the department (what students liked best): Many students commented positively about the faculty and staff: their accessibility and dedication. Several students mentioned the lab courses as a strength. At least one student mentioned each of helpful department chairs; small upper division class sizes; a variety of courses to prepare for graduate school and other students in the department.

4. Weaknesses of the department (what students liked least): The most common complaint was about advisement and in particular differences between A&S and the Chemistry Department, along with changing requirements and lack of communication about requirements and paths to graduate with a Chemistry degree. Several students reported having to stay longer to get their degree because of a failure in advising and failures in communication of information about when required courses would be offered. Also mentioned were issues related to information on Departmental Honors and ACS certification. Some students raised the issue of limited electives, old equipment and a few had specific complaints about particular classes and faculty.

5. What events, activities, or courses do you think are missing in the Department of Chemistry and Chemical Biology for undergraduates? Several students again raised the issue of wanting more options for electives, and suggested more events to allow students to get to know each other and also faculty members. At least one student mentioned each of wanting more options for internships; outreach to the Biology Department; reinstatement of Departmental Honors; more computer space; more options of times to take required classes and a coordinated system for finding out about lab experience early.
3. Summarize the faculty discussion of the assessment data. Describe any actions, program revisions, or assessment procedure revisions that were recommended by the faculty. If the faculty review was performed in a way that is different from that described in your approved assessment plan, describe the reasons for this and how the faculty review was performed.

Assessment for all of the classes in the approved Assessment plan (dated February 2009) has been discussed and evaluated extensively in the Undergraduate Assessment Committee (UAC) (which has the same membership as the departmental Undergraduate Studies Committee) at its regular weekly meetings throughout the assessment period. Results from these discussions are summarized above.

In addition, extensive assessment data were collected, discussed, and analyzed in detail for the large General Chemistry (Chem 121, 122) program, as part of the ongoing General Chemistry redesign project funded by the Department of Education. Results and conclusions from these assessments are included in Appendix A for the BSc report.

Regarding the exit survey feedback from students, discussions have been ongoing in the UG committee and the Department and have resulted in the following changes:

1. Improved ‘integrated’ advising for majors – the Arts and Sciences advisor for Chemistry and Biochemistry now has her office in the Chemistry Department. She has worked with the Department to develop materials to better inform students on their requirements and options.
2. Improved catalog information: based on student feedback, the semesters in which courses are normally offered is being added to the catalog to help students plan their path.
3. A department orientation/information session is held at least once annually in which majors and prospective majors can meet faculty and advisors, learn more about upper division courses, careers in chemistry and research opportunities.
4. The department has discussed the student concerns on inadequate information about ACS degree certification and, with the collaboration of the advisor, is implementing measures to ensure students are better educated at an appropriately early stage about the requirements for ACS certification.

Modifications to the plan:

The plan proposed presenting the results to all of the faculty at the annual faculty retreat. However, the faculty has not had an annual retreat for several years. As a result, the overall results of these assessment efforts will be discussed at the upcoming full faculty meeting, Wednesday Oct 29, 2014.

4. What will you assess during the next reporting period? How will you perform the assessment? Does this differ from your approved plan?
During the next period, assessment will be carried out as in the current period, with the following changes:

1) Since earlier efforts have resulted in a good understanding of the main issues for General Chemistry (Chem 121, 122), assessment activities in these classes may be reduced in favor or greater effort on higher-level classes.

2) Emphasis will increase toward gathering and evaluating fuller assessment data in: Chem 302 (Organic Chemistry, required of all Chemistry majors and many other STEM majors), Chem 315 (Introduction to Physical Chemistry, required for all BA Chemistry majors), and Chem 253 (Quantitative Analysis, required of all Chemistry majors).

3) A capstone class—intended to provide both a final program assessment opportunity for graduating Chemistry majors and to provide career-oriented experience and information—will be developed.

4) Optimization and improvements to the current exit interview program for Chemistry majors will be developed (perhaps in conjunction with the capstone class). In addition, the exit interview questions will be aligned with the program goals to allow comparison with the available direct measures.

**Plan Timeline:**

<table>
<thead>
<tr>
<th>SLO</th>
<th>Year 1: Course in which assessed</th>
<th>Year 2: Course in which assessed</th>
<th>Year 3: Course in which assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CHEM 302</td>
<td>CHEM 302</td>
<td>CHEM 302</td>
</tr>
<tr>
<td>a.</td>
<td>Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises</td>
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<tr>
<td>2.</td>
<td>2a CHEM 302</td>
<td>2b CHEM 253L</td>
<td>2c + 2d CHEM 253L</td>
</tr>
<tr>
<td>a.</td>
<td>Be able to employ critical thinking and hypothesis-driven methods of scientific inquiry</td>
<td>If 2a assessment is satisfactory</td>
<td>If 2b assessment is satisfactory</td>
</tr>
</tbody>
</table>
of data analysis
b. Use statistics to evaluate quantitative hypotheses
c. Critically evaluate experimental data
d. Extract chemical information from available resources

<table>
<thead>
<tr>
<th>3. Convincingly present scientific data and arguments in an oral and written format</th>
<th>3a: CHEM 253L</th>
<th>3b: CHEM 253L If 3a assessment is satisfactory</th>
<th>3c: CHEM 253L If 3b assessment is satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Organize and represent experimental data using appropriate methods (spreadsheets, etc)</td>
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<td>b. Be able to write coherent scientific reports</td>
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<td>c. Present scientific ideas and arguments</td>
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<tr>
<th>4. Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.</th>
<th>4a: CHEM 315</th>
<th>4b: CHEM 421 If 4a assessment is satisfactory</th>
<th>4d: CHEM 425 If 4b assessment is satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Apply general knowledge of chemical concepts to solve novel problems</td>
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<tr>
<td>b. Develop an awareness of the opportunities and applications of chemical knowledge to the world</td>
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<td>c. Obtain a working knowledge of basic chemical concepts, laboratory skills and safety</td>
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<tr>
<td>d. Develop scientific literacy and be familiar with the status of current research in the field of chemistry</td>
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<tr>
<td>e. Acquire general skills to work in small groups to accomplish scientific project</td>
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</table>
Periodic Report on Program Assessment of Student Learning

Academic year: **2013-2014**
Department/Program: **Chemistry and Chemical Biology**
Degree program(s): **BSc**
Person(s) preparing report: **UG Committee**
Date submitted: **October 24, 2014**

1. Describe the actions and/or plan revisions that were implemented during this reporting period in response to the previous period’s assessment results.

   *Although some assessment data has been collected systematically each year according to the assessment plan, it was not compiled and analyzed as a whole owing to changes in department administration. As such the assessment results reported here provide a baseline for the future.*

2. **a)** List the student learning outcomes (SLOs) that were assessed during this reporting period. If the assessment was performed in a way that is different from that described in your approved assessment plan, please describe the reasons for this and how the assessment was performed.

   1a. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises.
   2a. Solve problems using multiple layers of data analysis.
   3f. Interpret experimental results and draw conclusions.
   4. Convincingly present scientific data and arguments in an oral and written format.
      a. Organize and represent experimental data using appropriate methods (spreadsheets, etc)
      b. Write coherent scientific reports
      c. Present scientific ideas and arguments in a professional setting
   5a. Apply general knowledge of chemical concepts to solve novel problems

   **Proposed in plan:** SLO 2a in Dr. Whalen’s CHEM 302 course, 3f in CHEM 331L or 411L and SLO 5a in CHEM 253L

   **Current plan:** SLO 1a, 2a & 5a in Dr. Whalen’s CHEM 302 course, 3f & 4a, b, and c in CHEM 453L

   **Changes to plan for 2013/2014 assessment cycle:**

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University of New Mexico – Assessment
1. CHEM 331L was replaced by CHEM 453L. The instructor of CHEM 453L developed a capstone assignment in which students had to present their results that provided an excellent opportunity to assess not only 3f, but also all SLOS under the broad goal 4.

2. Assessment of SLO 5a was not carried out in CHEM 253L because of a change in instructor from the one who originally agreed to collect assessment data.

3. The original plan did not propose in which course to assess SLO 1a. CHEM 302 can cover both SLO 1a, 2a, and 5a.

b) Describe any developmental work that was done on your assessment plan, including developing new SLOs, creating new measurement methods, or amending your assessment plan.

Exit survey: The Department piloted an exit survey given to all graduating majors in Spring 2013 and Spring 2014. Primary areas of focus included strengths and weaknesses of the Department, significant courses and plans after graduation.

Rubrics were developed for the assessment of the SLOs 4a, b and c by the instructor of CHEM 453L. These rubrics are included in an appendix to this report.

c) Describe the results of the assessment. What did you learn about strengths and weaknesses of student learning in your program?

SLO 1a, 2a and 5a: (CHEM 302)

Questions aligned with course student learning outcomes “Interpret a $^1$H NMR spectrum and propose the structure of the compound that generates the spectrum; assign the proton environments,” and “Propose the 5-7 step synthesis of an organic compound from simple starting materials.”

Students were given questions on Exam I, II, III or IV that corresponded to the SLOs above. Their performance out of the maximum possible was recorded and the average for the class compared to the threshold for passing (70% = satisfactory). Chemistry BA and BS majors’ data were separated from the rest of the class for comparison. Data are included in the appendix.

In the 46-student Section 4, the 4 majors performed at the same level as the rest of the class for the entire semester on 6 of 7 questions. On the other 1, they performed slightly better
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Student performance overall was outstanding to good on questions involving NMR interpretation. Performance on questions involving synthesis dropped to satisfactory to less than satisfactory, with less than satisfactory to good results on questions where students were given boxes to guide their thought process and did not require creative action on their part. This has always been and will continue to be an area to target for improvement in instruction.

SLOs 3f, 4a, b and c: (CHEM 453L)

1. The average student score on the oral presentation was 88%, and all students scored above the 60% threshold proposed in the Assessment plan. Students demonstrated the following presentation skills
   a. Team presentation: every member of the group presents their portion and showed good coordination.
   b. Clarity: the majority of students explained the concepts, experimental procedures and data analysis well.
   c. Organization: all PowerPoint slides were well written and organized.
   d. Contents: the students knew the content well, argued with good rationale, and made correct conclusions.

2. More than 70% of the students asked questions during the presentations.

3. Experimental proposals: The average score of students’ proposal writing was 92.3%. All proposals were graded according to the rubric attached as an appendix. Two examples of proposal writing were also selected as good and poor.

4. Lab report writing: The class average of reports was 89.11%. All reports were graded based on the attached rubric. Two examples of reports are attached to show examples of good and poor.

Even though the protocols of proposals and lab reports were given to all students, they did not write their proposals and reports according to the protocols in the first three experiments. Students only started to comply with the protocols after the fourth experiment, and did not 100% adhere to the protocols. They need to learn the importance of following required format in writing scientific documents.
A weakness identified in the assessment procedure was the lack of external reviewer for the oral presentations. In future, for program assessment purpose, external reviewers such as faculty from the undergraduate committee will attend the oral presentations and provide feedback.

Other results:

Exit surveys were given to students graduating with a BA or BSc in Chemistry in 2013 and 2014. A summary of their responses to questions relevant to program assessment is presented.

1. Plans on graduating: Out of the 14 students responding to the survey, 6 intended to continue to graduate school in chemistry or biochemistry. 3 were either attending or applying to medical school. 2 intended to work in industry. 1 each were going to pharmacy school or to do a master’s in public health. 1 aimed for industry or academia.

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members. At least one student mentioned each of wanting more options for internships; outreach to the Biology Department; reinstatement of Departmental Honors; more computer space; more options of times to take required classes and a coordinated system for finding out about lab experience early.

3. Summarize the faculty discussion of the assessment data. Describe any actions, program revisions, or assessment procedure revisions that were recommended by the faculty. If the faculty review was performed in a way that is different from that described in your approved assessment plan, describe the reasons for this and how the faculty review was performed.

Assessment for all of the classes in the approved Assessment plan (dated February 2009) and the modified plan (explained above) has been discussed and evaluated extensively in the Undergraduate Assessment Committee (UAC) (which has the same membership as the departmental Undergraduate Studies Committee) at its regular weekly meetings throughout the assessment period. Results from these discussions are summarized above.

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Modifications to the plan:

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results of these assessment efforts will be discussed at the upcoming full faculty meeting, Wednesday Oct 29, 2014.

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2) Emphasis will increase toward gathering and evaluating fuller assessment data in: CHEM 302 (Organic Chemistry, required of all Chemistry majors and many other STEM majors), CHEM 411L, CHEM 432L and CHEM 453L, taken by most BSc Chemistry majors.

3) A capstone class—intended to provide both a final program assessment opportunity for graduating Chemistry majors and to provide career-oriented experience and information—will be developed.

4) Optimization and improvements to the current exit interview program for Chemistry majors will be developed (perhaps in conjunction with the capstone class). In addition, the exit interview questions will be aligned with the program goals to allow comparison with the available direct measures.

The original assessment plan did not include a 3 year timeline, and so one has been developed and is presented here.

Plan Timeline:

<table>
<thead>
<tr>
<th>SLO</th>
<th>Year 1: Course in which assessed</th>
<th>Year 2: Course in which assessed</th>
<th>Year 3: Course in which assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry a. Apply their understanding of atomic theory, molecular structure</td>
<td>CHEM 302</td>
<td>CHEM 302</td>
<td>CHEM 302</td>
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and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises

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<tr>
<th>2. Be able to employ critical thinking and hypothesis-driven methods of scientific inquiry</th>
<th>2a CHEM 302</th>
<th>2b CHEM 411L If 2a assessment is satisfactory</th>
<th>2c + 2d CHEM 411L If 2b assessment is satisfactory</th>
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<tbody>
<tr>
<td>a. Solve problems using multiple layers of data analysis</td>
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<td>b. Use statistics to evaluate quantitative hypotheses</td>
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<tr>
<td>c. Critically evaluate experimental data</td>
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<td></td>
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<tr>
<td>d. Extract chemical information from available resources</td>
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<tr>
<th>3. Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods</th>
<th>3f: CHEM 453L</th>
<th>3b: CHEM 453L If 3f assessment is satisfactory</th>
<th>3d: CHEM 453L If 3b assessment is satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Construct and test hypotheses</td>
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<td></td>
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<tr>
<td>b. Design experiments</td>
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<td>c. Use instrumentation to collect data</td>
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<td></td>
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<tr>
<td>d. Process data using a computer and use statistics to evaluate data</td>
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<td>e. Recognize, generate and analyze alternative explanations and models for experimental data</td>
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<tr>
<td>f. Interpret experimental results and draw conclusions</td>
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</tbody>
</table>
4. Convincingly present scientific data and arguments in an oral and written format  
   a. Organize and represent experimental data using appropriate methods (spreadsheets, etc)  
   b. Write coherent scientific reports  
   c. Present scientific ideas and arguments in a professional setting  
   
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<tr>
<th>Requirement</th>
<th>Course</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convincingly present scientific data and arguments in an oral and written format</td>
<td>CHEM 453L</td>
<td>Not needed – all done in year 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not needed – all done in year 1</td>
</tr>
</tbody>
</table>

5. Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.  
   a. Apply general knowledge of chemical concepts to solve novel problems  
   b. List and explain some of the opportunities and applications of chemical knowledge to the world  
   c. Have a working knowledge of basic chemical concepts, laboratory skills and safety  
   d. Demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry  
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<td>Be prepared for entry into graduate school or professional school</td>
<td>5a CHEM 302</td>
<td>5e CHEM 432L If 5a assessment is satisfactory</td>
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<td></td>
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<td>5c CHEM 432L If 5e assessment is satisfactory</td>
</tr>
</tbody>
</table>

University of New Mexico – Assessment  
Appendix A: CHEM 121 Course Redesign Annual Report 2014

1. Project motivation and goals: A brief explanation of the motivation of the redesign project and the goals that were established at the outset (along with any modification of goals that were developed during the year)

General Chemistry I (CHEM 121) is a gateway course for majors in science and engineering. CHEM 121 shares the same learning difficulties as CHEM 122, resulting in similarly high W/D/F rates, and preventing many students from continuing with their chosen STEM major. We intended to use our experience from a successful redesign to return to CHEM 121. In CHEM 121, we face a problem that is less apparent in CHEM 122, motivation for learning chemistry. Unlike CHEM 122 students who have oftentimes made their decision as to their field of study, many CHEM 121 students are not sure why they need to learn chemistry. The CHEM 121 students are also less familiar with the college setting, putting them at a disadvantage in terms of metacognitive skills. We proposed to improve student motivation, learning and retention in CHEM 121 by a course re-design emphasizing active learning, interdisciplinary exercises and multi-component assessment.

Of the 1300 students who take CHEM 121 each year at UNM, less than 5% go on to become chemistry majors; of the remaining 95%, nearly half become biology and pre-health science majors, while about a quarter become engineering majors. Incorporating the needs and expectations of these departments into the course learning outcomes is essential if CHEM 121 is to remain relevant as a gateway STEM course. At the same time, outcomes must be related to subsequent chemistry courses (CHEM 122/124L) to keep students up to date in chemistry and prepare them for advanced topics.

Extensive research points to improved student learning when using active learning pedagogies in the classroom. A significant study suggests that using these methodologies in the classroom can make more difference to student learning than the choice of instructor to teach them. In order to make time in the classroom to engage in such activities, we used an “inverted classroom” approach, where the acquisition of the basic facts and concepts becomes the responsibility of the students before class, via structured reading assignments or online resources. Class time is then be focused on more difficult concepts, applications and synthesis in which the instructor and peer-learning facilitators help students engage with exercises designed to explore the outcomes. Clicker questions are used to assess learning in these exercises, but also as a tool to promote student participation and engagement.

Exercises utilize pre-class reading with in-class problem solving and optional post-class follow-up reading to see how the problem is solved in the “real world” of application. A major focus of our redesign was to target known misconceptions and student difficulties and we aimed for Bloom’s taxonomy levels above simple
knowledge and comprehension to application and above. Use of open source educational resources including the Journal of Chemical Education allow the exercises to be textbook independent. Peer learning facilitators were employed in larger sections to ensure that student groups remain “on track” during in-class exercises.

2. **Project summary**: Summarize the instructional redesign components (this will likely come from the proposal along with modifications that may have been made)

- Established course learning outcomes that align with HED competencies and STEM major requirements. This was done in the summer of 2013.
- Developed structured pre-class reading assignments and formative assessments to enable students and instructors to monitor acquisition of basic facts and concepts before class. This was done in the summer of 2013 and revised during the winter break of 2013/2014.
- Created in-class, interdisciplinary exercises and questions which require higher-order thinking with optional follow-up references. These are combined with clicker questions that test these higher levels of thinking for assessment in the large classes. This was done in the summer of 2013 and revised during the winter break of 2013/2014.
- Created a detailed multicomponent assessment plan for the initial implementation. The assessment includes modified chemistry concept inventory, implemented as pre- and post-test, common core questions in four 50-minute exams, and a common final exam. These assessments were implemented in the fall and spring semesters of 2013 and 2014. The pre-test was implemented during the first week of each semester and the post-test during the week 16 of each semester. The common core questions were given by all sections during the same week. The common final exam was written by faculty not teaching CHEM 121 during these semesters, and implemented during the scheduled final exam time using scantrons. Data generated from all assessments mentioned were analyzed and discussed – see the conclusions in the assessment section.
- Developed subject-specific training for learning facilitators (TAs, SI and PLFs in the classroom). Each faculty member provided section-specific training for their learning facilitators, and discussion included common student errors on course materials as well as general trouble-shooting on issues raised by the facilitators.

3. **Assessment**: Present any and all data obtained as part of the originally stated or modified assessment plan that are related to students’ (a) learning (e.g., outcomes assessment data, pre/post-test or concept-inventory results), (b) success (e.g., grades), and/or (c) attitudes (e.g., surveys). These data
should be briefly interpreted.

A. Normalized concept gains, comprehensive final exams and percentage passing rate

The trends of the final exam averages, normalized gains averages, and percentage passing grade average in the last 5 semesters were summarized in the figure above. The fall semester of 2013 is the first semester we implemented the redesigned CHEM 121 material. The averaged normalized concept inventory gains data of fall 2013 showed a significant surge. Although the gains in the spring semester of 2014 dropped, they are still higher than the corresponding spring 2013 semester, and we believe the average gains will reach an equilibrium in the near future, similar to the trend we observed in the CHEM 122 redesign. A greater spectrum of students’ background and maturity in CHEM 121 are also contributing factors for such wide fluctuation of the performance.

The slight decline of percentage passing rate has many possible reasons that are not related to the trend of concept inventory gains. Before the spring of 2013, while the average concept gains declined, the passing rate increased. When the gains increased in the fall of 2013, the passing rate decreased further. We believe the contributing factors to the decline of passing rate are not directly related to student’s performance in the pre- and post- concept inventory tests or the final exams. Other factors in the final calculation of course grade might be determining effect of such decline. Among them, the homework assignments and in-class discussions are two main factors, as well as individual faculty member policies.

Although the trends shown here are not as encouraging as we would hope, we believe the
changes from semester to semester can be explained by the standard deviations of the means and a longitudinal study will provide an opportunity for more data collection to resolve this uncertainty. We should delay our conclusion at this point about the effect of redesign courses on student’s performance.

B. Students’ Mathematical Background and their performance

**Fall 2013**

<table>
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<tr>
<th>grade</th>
<th>121</th>
<th>123</th>
<th>150</th>
<th>162</th>
<th>163</th>
<th>180</th>
<th>ACT/SAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.1</td>
<td>20.0</td>
<td>11.1</td>
<td>45.5</td>
<td>60.0</td>
<td>22.2</td>
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<td>B</td>
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<td>54.5</td>
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<td>0.0</td>
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<td>0.0</td>
<td>22.2</td>
<td>25.6</td>
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</tbody>
</table>

The above table was generated to show the CHEM 121 grade distributions from students taking a particular math course (121, 123, etc) a semester prior to taking CHEM 121. For example, column one contains students in CHEM 121 for the fall of 2013 who had taken Math 121 in the Spring of 2013. Among these students, 10.1% got an A, 24.7 % got a B, etc. Overall, 39.3% of these students failed CHEM 121.

From the above table, students from the two calculus courses have 100% passing rate, and generally speaking, the higher number math course students took, the greater the passing rate in CHEM 121. Students used ACT or SAT scores as the pre-requisite for CHEM 121 have the passing rate similar to higher Math course number, such as 150 and 180. We can therefore, conclude that completing MATH 121 is not equivalent to ACT/SAT requirement in terms of math preparation for chemistry.

C. *Correlation between Math courses & Assessments (spring 2014)*
The first table contains the averages of each assessment students in CHEM 121 scored (out of 100) based on the Math course they took in the previous semester. Once again, students took calculus (MATH 162 and 163) have higher pre and post score, and the highest gains (10.68 and 20.59%). From other math courses, the higher the course number, the greater the gains. In this case, students from ACT/SAT group scored about the same as those came from MATH 121.

D. Mid-term assessment data

We pinpointed topics of concern by discussing common midterm questions on which students did not perform as well as expected, using these as a guide for revising or adding material for future terms.

One area of concern tracked by the common midterm questions was students’ well-known difficulty conceptualizing mass on the atomic scale. For example, students were asked the
mass of one atom of carbon-12; many students incorrectly chose ‘12 g’ or ‘both 12 g and 12 amu’ instead of ‘12 amu’. Instructors targeted this concept as one for additional in-class exercise work. Subsequently, percentages of students answering the question correctly increased from 37.3% to 49.5% in sections taught by the same instructors the following term.

E. Student and faculty attitudes toward redesigned courses

In general, students’ responses to the redesign have been favorable. Responses solicited from instructor surveys include:

• “Class is interesting and the worksheets give me a good idea of what kinds of questions to expect on an exam. Because we work through example problems in class every day I feel more comfortable with the material and don’t have to study outside of class as much as I normally would. Practical application is the best way for me to learn a concept or equation.”

• “I enjoy this class very much. Although it is challenging and a lot of work, I enjoy the challenge and the in-class exercises and being able to work in groups and ask questions throughout is extremely helpful as opposed to just a straight lecture class.”

• “The in-class work and working in groups really helped me a lot because not only could I ask for help from the PLF and professor, my classmates made it easier for me to understand what the concept was about.”

• “Because we are expected to read certain sections before class, ... lecture leaves out a lot of information that makes it so the people who had to work late or just didn’t get to do the reading are completely lost.”

One instructor asked students to report their attitudes toward the active learning aspects of the course redesign (specifically, in-class exercises, PLF-supported group work, and clickers were used); in Fall 2013 there were 64 respondents; in Spring 2014 there were 101 respondents.

Students overwhelmingly appreciated in-class exercises and group work opportunities. Specifically, they pinpointed the ability to work with their peers and access differing methods for approaching the same question as one of the key benefits to the redesigned course; several students also appreciated having immediate access to PLFs and/or the instructor to resolve questions or provide aid. The most common negative points involved dissatisfaction with the grading scheme or the amount of time spent on lecture versus in-class exercises.

<table>
<thead>
<tr>
<th></th>
<th>Fall 13</th>
<th>Spring 14</th>
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<tbody>
<tr>
<td>in-class exercises/clickers were beneficial to learning</td>
<td>46 (79.3%)</td>
<td>73 (83.9%)</td>
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</table>

University of New Mexico – Assessment
program_assessment_of_student_learning_BS FALL 2014.docx
As shown in the two graphs below, when asked specifically about the time management of class activities, significant numbers of students wanting some adjustment. However, there was no consensus on what specific adjustments should be made (in these particular sections of 121, roughly equal amounts of time were spent on lecture and active learning).

<table>
<thead>
<tr>
<th>Comment</th>
<th>F13 (%)</th>
<th>S14 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>... because working with peers was valuable/hearing different perspectives or methods of solving a problem was useful</td>
<td>11 (18.9%)</td>
<td>29 (33.3%)</td>
</tr>
<tr>
<td>... because I was able to receive immediate help from PLFs and/or my instructor</td>
<td>7 (12.0%)</td>
<td>14 (16.0%)</td>
</tr>
<tr>
<td>... but working as a group should be incentivized/more encouraged</td>
<td>0 (0%)</td>
<td>2 (2.29%)</td>
</tr>
<tr>
<td>The grading system (correct = 2 points, incorrect = 1 point) should be changed</td>
<td>2 (3.44%)</td>
<td>6 (6.89%)</td>
</tr>
<tr>
<td>A different order of clickers vs lectures would have been better</td>
<td>5 (8.62%)</td>
<td>4 (4.59%)</td>
</tr>
<tr>
<td>In-class exercises were not beneficial or detrimental to learning</td>
<td>6 (10.3%)</td>
<td>7 (8.04%)</td>
</tr>
<tr>
<td>... because they took away from lecture time</td>
<td>5 (8.62%)</td>
<td>3 (3.44%)</td>
</tr>
</tbody>
</table>

Faculty responses to incorporating the redesign were also generally favorable. Instructors generally reported an increase in student engagement with the material, student engagement with the instructor, attendance increases, but also that switching methods had a steep learning curve. Encouragingly, several instructors have gone on to incorporate active learning techniques in higher level courses they teach (e.g., organic) and an instructor who did not participate in the redesign in Fall 2013 chose to incorporate redesign elements in Spring 2014.
• “Having spent many semesters thinking about how to improve student learning in General Chemistry and trying out different tactics in isolation, being a part of the course redesign teams has been invaluable. The opportunity to share my own experiences and learn from ideas and responses from others has helped me improve my teaching more and faster than I was able to do on my own.”

• “My biggest challenge, compounded by being a new instructor, was time management of lectures vs in-class work.”

• “Having the strong faculty community and pre-prepared materials available for modification was invaluable…”

• “When prepping for the first semester of teaching 121, I found using all of the redesign a bit overwhelming, so I decided to pick and choose, and gradually add pieces in over several semesters.”

4. Improvement: Provide a summary of the curricular and pedagogical changes you are planning to make in light of the collected assessment data and your teaching experiences.

• Using ALEKS as the pre-semester preparation for students. Assessment data showed that students in CHEM 121 have various academic background and mathematical preparation. Even students who had taken high school chemistry appear to have forgotten most of what they learned in high school. We feel it is beneficial for our students to take an initial assessment about their prerequisite knowledge before starting the semester and refresh their memories for chemistry. ALEKS is a self-paced program for this purpose. We will offer ALEKS to students in the fall semester of 2014 two weeks before the semester starts and extend two weeks after the semester starts. Students’ performance will be monitored and analyzed for any difference between those who practice ALEKS and those who do not. During Winter Break, we will determine if use of ALEKS will be continued in the spring or not.

• Online lecture: we will explore the possibility of developing online mini-lectures in support of student learning where we feel that the textbook reading assignment does not seem to adequately prepare students for class.

• Assessment methodology. Instead of looking at assessment data in the aggregated manner (mean values of test results), we will start to look for performance trend based on groups of students, such as quintile or social-economical status. We will also like to assess questions like “How many students read the textbook?” and “Is Mastering Chemistry effective for our students’ learning?” We also like to obtain more data about student’s perspective of the reformed course using surveys.

• Continue refinement of course material and assessment questions. A list of difficult concepts and misconceptions has been constructed from item analysis of the final exam. We will generate new material to address these difficult concepts to be used in the fall semester. Ineffective questions from the past assessments were also identified using the scantron reports. These questions will be
either modified or avoided in the next assessments used for fall and spring semesters.

- Interdisciplinary exercises can motivate students by the area of application and the level of conceptual integration, and engage higher-order reasoning skills. We should develop more examples in engineering, health sciences and geochemistry since a major goal will be to show students how CHEM 121 principles can be applied in different STEM fields.

5. **Expansion**: Outline your plan for continuation of the redesign project, which should include an indication of the approximate number of sections of the course that will be taught using the redesign in Fall 2014 and Spring 2015 and (b) who the likely instructors will be and/or how those instructors will be recruited. If, compared to Spring 2014, there will be no increase, or there is a decrease, in the number of sections taught with the redesign, then please provide a rationale.

All sections of CHEM 121 participated with some aspects of the redesign in Fall 2013 and Spring 2014. We have included all sections of our CHEM 121 in our reformed project in the fall semester of 2014 and intend to continue this arrangement in the near future. No expansion plan is necessary for our team.

6. **Sustaining**: A plan for sustaining the curricular and pedagogical innovations of the redesign. This section should include (a) achievements and/or intentions for accessible curation and dissemination of redesigned instructional components, (b) plans for continued work by the team to assess outcomes and make adjustments for continuous improvement, and (c) plans for assuring successful, self-efficacious implementation of the redesigned course elements by instructors who were not part of the original team.

- We have found the faculty weekly meeting to be very effective for sustaining practice of the reform effort, as well as supporting instructors who are new to the style of teaching. At these meetings, instructors set core exam questions, discuss assessment results and troubleshoot issues together that individual instructor’s face. We will continue this practice indefinitely.
- We will implement a faculty start-up meeting to better coordinate the reform effort and training for faculty members first-time teaching CHEM 121.
- Conference presentations. We have presented our project in Success in the Classroom, New Mexico Higher Education Assessment & Retention conference, NSF Analytical Chemistry Active Learning workshop, and will present in Biennial Conference of Chemical Education in August.
- A Departmental Website will be created in the fall to host reform material for New Mexico higher education communities and provide social network for faculty who wants to adopt the practice.

All team members should participate in these processes and teams are encouraged to commit to some face-to-face meeting time for that purpose. STEM Gateway redesign project staff will attend a session
with each team at the beginning or very early during these summer activities, at any time during the summer at the request of the team leader (or individually with team members), and will also meet with each team leader after submission of the report.
Team members:
K. Joseph Ho, Sushilla Knottenbelt, Shaorong Yang, Clarissa Sorensen-Unruh, Sarah Toews-Keating

Date: August 1, 2013

Summary
The CHEM 122 Redesign project started in the summer of 2012, and implemented in one section of the fall semester of 2012, and expanded into all sections of the spring semester of 2013 and thereafter. Data presented in this report were collected from these two semesters. Although there is not significant change of students’ performance in terms of course grades since the implementation of the reform, more significant improvements of the reformed classes have been observed in concept gains, especially the concepts covered in the CHEM 122 Course Learning Outcomes.

Figure 1. Passing (green variants) and D/W/F (red/orange variants) data for CHEM122 students who received a grade at the end of the term, excluding drops, audits, CR, I, and NC. The D/W/F rate is defined as ‘Failure rate’ for the remainder of this report.

Background information:
- Fall 2011: one year prior to the reform
- Spring 2012: one semester prior to the reform
• Fall 2012: first semester implementation of the reformed course. Only one section (section 4) was selected (about 35 students). Sections 1 and 2 were taught traditionally. Section 3 was a fully online course, primarily delivered using video lecture.
• Spring 2013: The second semester of implementation. All sections were taught as reformed courses.

Analysis:

1. There is a significant difference between the fall and the spring semesters from all categories of grades. Students normally enter the sequence in the fall (for CHEM 121) and move on to CHEM 122 in the spring semester. Therefore, the Spring semester is the on-cycle semester for CHEM 122. It is expected to observe different performance in CHEM 122 between the fall and spring due to students’ background. In general, we have seen higher failure rates in the Fall semester than in the Spring semester. The percentage of students receiving A and B are also higher in the spring semester.

2. A noticeable difference between the Fall 2011 and Fall 2012 for the percentages of students receiving A’s (13.7% vs 8.9%) could be a sign of the effect of the reformed approach. However, the fall 2011 semester still shows better performance in terms of Failure rate, B’s, and C’s. Because of the small number of students in the test group (35), the Fall 2012 group is dominated by the population of students taught using a traditional approach.

3. The spring semesters are more troublesome for the interpretation. Although the plain numbers from the grade data indicate a worse performance in 2013, the differences are not statistically significant. Unfortunately, we don’t have the data from the same pre-test to compare students’ entrance scores between the two semesters. (The average of the pre-test from the spring of 2012 is 53% whereas that from the spring of 2013 is 37.39%. The two tests have about 85% common questions.)

4. Another factor that cannot be ignored is the variation of grading scale by different instructors. The practice of grade assignment by different instructors can affect the distribution of passing and failure rates.

Figure 2. Conceptual Gains between Spring ‘12 and Spring ‘13. The conceptual gains were calculated as the post-test score –
pre-test score. These are not normalized gains.

**Analysis:**
Because of the Fall-Spring differences in students, we will compare Spring 2012 to Spring 2013. Although the overall grade distributions appear similar (or perhaps even a bit worse in Spring 2013 than Spring 2012), analysis of gains on the pre- and post-concept inventory shows a significant shift to greater gain. The average student gain shifts to ~+20% in spring 2013 from ~10% in Spring 2012. This suggests that students taking the redesigned course show a greater conceptual gain over the semester.

This comparison shows a different trend than what is revealed in Figure 1 where fewer students received A and B, more students received CDWF in spring 2013. Although the reformed classes did not demonstrate learning advantages in grades, students from these classes demonstrate greater conceptual gains. The better learning in the concepts is believed to help students’ performance in the advanced courses later in the program.

**Analysis**
In Fall 2012 and Spring 2013, identical final exams were given. The redesign pilot section had the highest exam average (despite having a lower pre-concept test average) of the 3 sections taught. In Spring 2013, all sections were taught with the redesign, and showed improved final exam scores than the control groups in the Fall. Again, this could be due to the Fall-Spring section difference, and
although a common final exam was given in Spring 2012, it was not the same one used in Fall 2012 and Spring 2013.

Although the differences among sections are small, the general trend is clear. In the Fall of 2012, the control group (section 1 and 2) consistently had lower averages than the test section (4). In the spring of 2013, all sections are test groups and their averages are similar, except for section 5 which is a BA/MD section. The two sections with the highest averages were taught by the same instructor. The sections range in size from 23 students to 250 students, and there was no obvious relationship of average final exam score and class size.

Figure 3 Normalized conceptual gains by section and with 121 questions separated from 122 questions.

**Background:**
The averages of 121 and 122 questions were calculated separately in this analysis to reveal the conceptual gains in each set of questions. In general, the 122 concepts build on 121 concepts.
The normalized gains was calculated as (post score – pre score)/ (100 – pre score)x100%.

**Analysis:**
All redesigned sections show significant improvement in CHEM 122 concepts, ranging from 21 to 29%. The control sections had gains of about 16%. Interestingly, the control sections show a better gain on CHEM 121 material than the redesign sections, but this may be a function of the Fall-Spring difference rather than the redesign.

**Background:**
The performance gains for Fall 2012 were calculated as the absolute gains defined. The test section is plotted in red.

**Analysis:**
The averaged gains of ABC students are significantly higher than those of DWF students by at least 5%.

The control sections show gains in proportional to the grades. The A students show higher gains than the B students, etc. However, from the test section, the average gain of C students is higher than B students; all grades show similar averaged gains. It is believed that the reformed approach provides a more balanced attention to all grade groups of students.
Background
The Colorado Learning Attitude in Science Survey (CLASS) was given to all students on week 3 and week 16 of the fall semester of 2012. Section 4 is the test section for the reformed course. The gains were calculated as the absolute gains.

Analysis
In Fall 2012, all sections showed gains on the Colorado Attitudes to Science Survey, with the pilot section (section 4) starting out the most positive and ending the most positive, with the 2nd largest gain. Interestingly, the largest gain was observed in the online section – section 3. Although the pre and post CLASS was not complete in Spring 2013, the instructor of the largest redesign section (N = 250) collected results of a mid-semester survey in which students rated the effectiveness of particular components of the redesign for their learning. Results of these are shown below, with total number of students on the y-axis.

Q1: How well do the reading assignments and quizzes prepare you for class? (1-5 where 1 = not at all and 5 = very much)

Q2: How effective are in-class exercises in helping you learn the material? (1-5 where 1= not at all and 5 = very much)
Conclusion

The course redesign project was successfully scaled up from a single pilot section in Fall 2012 to all sections (4 sections total, 3 different instructors, of which one was not a member of the redesign team) in Spring 2013. The redesign materials were used in classes as small as 23 and as large as 250. Although course grades data does not yet reflect significant differences between student outcomes in the redesigned classes and in traditional classes, we do see a significant gain in a chemical concept inventory given pre- and post-class. With multiple instructors with different grading policies and many components, course grades can be difficult to compare, and as such, we are encouraged by the improved gain on the concept inventory. In addition, students respond well to the redesign (improvement in the CLASS attitudes to science survey, Fall 2012), and rate the components of the redesign as having a net positive effect on their learning (mid semester survey in 250 student CHEM 122 section, Spring 2013). We are continuing to analyze the course materials that corresponded to significant concept gains to recommend their use, and will work to improve course materials in areas that still show poor concept learning. Thus, the redesign will continue as an iterative process, and will benefit from discussions with new faculty teaching the courses and using the materials.
## General Raw Data for Pre, Post, Final, and Gains data, Spring and Fall

### Spring 13

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<th>mean (final exam)</th>
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<th>post</th>
<th>#</th>
<th>%</th>
<th>gains%</th>
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### Fall 12

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<td>26.0606</td>
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<td>22</td>
<td>12.09</td>
<td>6.97</td>
</tr>
<tr>
<td>35 F</td>
<td>27.7778</td>
<td>31.1111</td>
<td>6</td>
<td>3.3</td>
<td>4.62</td>
</tr>
<tr>
<td>W</td>
<td></td>
<td></td>
<td>21</td>
<td>11.54</td>
<td></td>
</tr>
</tbody>
</table>

### Notes

- The data includes pre-test, post-test, final exam scores, and gain percentages for different classes.
Appendix C. Rubric for CHEM 453L proposal and report writing

Rubric for proposals
List of chemicals/equipment: (50 points)
- No list provided (0)
- Incomplete list of chemicals; missing important safety information; incomplete consideration of equipment (10)
- Have included most chemicals and equipment; missing some minor information of safety (30)
- Complete chemical and equipment lists; good summary of safety information (50)

Experimental procedure (50 points)
- Clear description of the procedure (10)
- Give good rationale for the plan (15)
- Appropriate procedure for experimental objectives (15)
- Good plan for time management (10)

Rubric for reports (100 points)
1. Changes of your approach from the proposal and the reasons for the changes,
   - Section included (5 points)
   - Clear statement of procedure changes and good rationale (5 points)

2. Final version of chemical/equipment list (10 points)

3. Experiment dates (actual) (5 points)

4. Summary of data
   - Summarize data clearly (for example tables) (10 points)
   - All data include units (5 points)
   - All data recorded with significant figures (5 points)

5. Data analysis
   - Spreadsheet is used (10 points)
   - Correct calculation steps (example is included) (10 points)
   - Charts are corrected made (labels) (10 points)

6. Conclusion
   - Arguments were made with claims, evidence and rationale (10 points)
   - Conclusion is made for the lab questions. (10 points)
   - Writing style (5 points)
## CHEM 453L Student Group Presentation Rubric

<table>
<thead>
<tr>
<th></th>
<th>Excellent 4 pts</th>
<th>Good 3 pts</th>
<th>Fair 2 pts</th>
<th>Poor 1 pts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
<td>Presentation was very organized and was very easy to follow. Transitions between group members were well planned and executed cleanly.</td>
<td>Presentation was fairly organized and pretty followable. Transitions might have been slightly discontinuous but did not take away greatly from the overall presentation.</td>
<td>Presentation was not clearly organized. Transitions between members were jumpy or awkward.</td>
<td>Presentation lacked organization. Poor transitions between group members. Individual parts. Presentation lacked order and very difficult to follow.</td>
</tr>
<tr>
<td><strong>Teamwork/Participation</strong></td>
<td>The group worked very well with each other and the presentation was shared equally among the group members.</td>
<td>The group worked well with each other and communicated well. Some members participated slightly more than others.</td>
<td>Group communicated relatively well with a few lapses in the presentation; some students dominated the presentation and others did not participate much.</td>
<td>Group did not work well together. There were obvious miscommunications and lapses in the presentation.</td>
</tr>
<tr>
<td><strong>Content - principles</strong></td>
<td>The group covers all principles and explains clearly</td>
<td>The group covers key principles and or has some confusion explaining it</td>
<td>The group cover some principles and or make several mistakes</td>
<td>The group covers little principles and or has not understanding of the principles</td>
</tr>
<tr>
<td><strong>Content - Experimental</strong></td>
<td>The group explains the rationale and process of experimental design and shows excellent problem-solving</td>
<td>The group has explained how experiment was designed and carried out for the most part, and or has not demonstrated good problem-solving skills</td>
<td>There are some problems with experimental design and or the execution of the experiment and or problem-solving skills</td>
<td>The group demonstrated little ability in experimental design and or execution of procedure.</td>
</tr>
<tr>
<td><strong>Content – data analysis</strong></td>
<td>The group has shown correct data analysis and is able to make sensible conclusion. The group is also demonstrated ability to learn from mistakes.</td>
<td>The group has shown correct approach with a few mistakes in data analysis and conclusion.</td>
<td>The group has shown significant mistakes in data analysis and conclusion.</td>
<td>The group has not able to demonstrate ability to process data and make conclusion.</td>
</tr>
<tr>
<td><strong>Visual Aid(s)</strong></td>
<td>Visual aids used were used effectively throughout presentation. Group members used visual aids as a supplement, not as a crutch.</td>
<td>Visual aids used were somewhat effective, but weren't used consistently throughout presentation.</td>
<td>Visual aids used did not support verbal presentation. They lacked information, or groups members read from them.</td>
<td>Visual aids were not used at all.</td>
</tr>
</tbody>
</table>

---

University of New Mexico – Assessment  
A Sample of Good Proposal

Analysis of Dextromethorphan in Cough Syrup and Cough Drops - Experiment Proposal

Name removed Potential Date: 2/18/14

This experiment is based on the principle of fluorescence (Figure 1). Fluorescence, involves the excitation of ground state electrons to higher electronic states through bombardment with sufficient energy photons. Once excited, the electrons can undergo one of three transitions, Rayleigh, Stokes, or Anti-Stokes. Stokes and Anti-Stokes are considered forms of Raman scattering. These transition to lower energy states releases a photon with an identical, longer, or shorter wavelength than the incident photon according to Rayleigh, Stokes, or Anti-Stoke transitions. However, it should be noted that most fluorescence is the measurement of stokes shifted photons. This experiment attempts to analyze the dextromethorphan concentration in both cough syrup and drops through fluorescent measurements. Because there are other ingredients present in the syrup and drops I will use the standard addition method to negate the matrix effects. In this method known concentrations of standards are added to the unknown sample and diluted to a constant volume. This will allow for the comparison between the sample and standards using a calibration curve.

Chemicals:

<table>
<thead>
<tr>
<th>Name</th>
<th>Supplier</th>
<th>MW (g/mol)</th>
<th>Boiling °C/MeltingPoint °C</th>
<th>Density (g/ml)</th>
<th>Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tussin DM</td>
<td>Equate</td>
<td></td>
<td></td>
<td></td>
<td>Do not take if taking a prescription for monoamine oxidase inhibitor</td>
</tr>
<tr>
<td>Sore throat + cough</td>
<td>Chloroaseptic Total</td>
<td></td>
<td></td>
<td></td>
<td>Do not take if have allergy to local ‘caine’ anesthetics. (e.g. benzocaine, cocaine)</td>
</tr>
</tbody>
</table>

Figure 1. A schematic of fluorescence is presented
### Equipment:
Fluorometer, 8-25mL volumetric flasks, 8 small beakers

### Hypothesis:
Manufactured cough drops and syrup have a specified amount of dextromethorphan in each does. Using fluorescence spectroscopy we hypothesize that there is at least the specified amount of dextromethorphan in each does of both cough drops and cough syrup.

### Procedure:
1. This experiment will use standard addition because of the appearance of many components in the matrix of both the drop and the syrup. These components are expected to have a large effect on the matrix which will be nullified using the standard addition method. Standards will be prepared using 5 solutions with concentrations ranging from 0-2mg/mL dextromethorphan. In each standard 1mL of dextromethorphan containing cough drop or syrup (approximately 0.5mg/mL according to the boxes) will be added. Each standard will then have increasing amounts of dextromethorphan and is then diluted to 25mL. The samples will then be measured. A calibration curve will be made by plotting absorption on the y axis and concentration on the x axis. An equation relating the two axes will be generated and an r squared test used to determine the correlation coefficient. A spike recovery test will then be used to determine if the data can be considered valid. This test is preformed by measuring the absorbance of a known standard and the concentration is found. Following, a known amount of dextromethorphan is added to the sample, and a new concentration found through and absorbance reading. The Spike recovery equation is then applied. If the equation results in a percent is near 100, the data is valid.

\[
\%R = \frac{C(\text{spike}) - C(\text{sample})}{(\text{Vol.1 sample solution* Con.1 sample solution} + \text{Vol.2 addition solution* Con.2 addition solution})/ \text{ Vol. total}) - C(\text{sample})}*100\%
\]

2. The wavelength will be determined through a scan using excitation of 260nm and reading from 286 to 500nm using a 1nm slit width. In this range we expect to find an emission at 307nm for dextromethorphan which was confirmed upon trial. These parameters were all found using literature searches and experimentation with the instrument and samples.

3. The cough drop unknown will be prepared by grinding it in a mortar and pestle and dissolving it in 25mL. Because there are 5mg of dextromethorphan in each drop, according to the manufacture,
the solution should be approximately 0.5mg/mL. This concentration was also created, according to the manufacture’s label, for the syrup. The drop and syrup will be dissolved in water because it is the main component in the syrup and the drop. Additionally, we feel it more consistent to use water for the drop, so that they experience similar matrix effects and will make any comparison’s more valid. For each trial we plan to take 10 readings. This will provide sufficient evidence to support our data while still being time efficient during the lab period.
A sample of Poor Proposal

Experiment 3: Analysis of Dextromethorphan in Cough Drops and Liquids

Name removed

In this experiment we will be determining the concentration of Dextromethorphan (DM) in OTC products. A spectrofluorometer will be used to determine and measure the concentration of the stock solution of DM and the DM concentration in the OTC product. The chemicals needed for this experiment out DM, OTC product and water. Equipments needed in this experiment our spectrofluorometer, cuvettes, beakers, volumetric flasks, pipettes, glass pipettes, bulb, kim wipes, measuring scale, funnel, and computer. The experimental procedure of this experiment is to make a stock solution of DM in a volumetric flask. Five different solutions using the cough syrup will be made and adding different amounts of spike to each of the solution. Standard addition method will be used and different spike amounts will be added. The solution will be made in 10mL volumetric flasks. Each of the solution will be scanned around 270nm wavelength and slit width of 5 or 10. The wavelength and the intensity will be measured of each of the solution and will be used to create the calibration curve. This experiment was performed with Katelin Hartwig and Azaria Brooks on February 17th and 19th.
A sample of good report

Verifying the Concentration of Dextromethorphan in Cough Drops Using Fluorescence Spectrophotometry

University of New Mexico, Department of Chemistry and Chemical Biology
30 March 2014

Abstract

Of the active ingredients in cough drops and liquids, Dextromethorphan (DM) acts as the cough suppressant. In this experiment, we have verified that the reported 5mg/lozenge of DM in a Chloraseptic Total cough drop is close to the amount of DM contained in the cough drop analyzed. The sample was analyzed using fluorescence spectroscopy and the method of standard addition. The DM concentration was determined by the standard addition calibration to be 6.2 mg/lozenge.

Chemicals and Equipment

The required chemical and amounts needed are shown in the table below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Formula Weight</th>
<th>Physical Properties</th>
<th>Hazards</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextromethorphan Hydrobromide Monohydrate</td>
<td>C_{16}H_{20}NO.HBr.H_{2}O</td>
<td>370 g/mol</td>
<td>white solid, mp = 122-124 °C, absorbs at 278 nm, soluble in water and ether, insoluble in chloroform</td>
<td>Toxic by ingestion, Target organs: lungs, Harmful if inhaled.</td>
<td>8 mg; lozenge containing 5 mg</td>
</tr>
</tbody>
</table>

The list of required equipment is as follows: mortar and pestle; 100 mL volumetric flask; 500 mL volumetric flask; five 10 mL volumetric flasks; powder funnel; 500 – 5000 µL pipette; 100 – 1000 µL pipette; five 100 mL beakers; 250 mL beaker; 10 x10 mm fluorescence spectrophotometer cell; and the Cary Eclipse Varian Fluorescence Spectrophotometer.

Experimental

This experiment was performed on March 13, 25, and 27, 2014. Four separate trials were performed before conclusive data was obtained. The data from Trial 4 was used in the data analysis and conclusion.

Preparation of Starting Solutions

For trials 1 and 2, the lozenge solution was approximately 0.05 mg/mL and 0.02 mg/mL, respectively, using the method described below. A standard solution of a concentration of 0.172 mg/mL for both trials was used in trials 1 and 2. For trials 3 and 4, we prepared the lozenge by crushing it with a mortar and pestle then dissolving it in deionized water to a volume of 500.0 mL. This would make the concentration of the lozenge solution approximately 0.01 mg/mL,
according to the reported concentration of 5 mg/lozenge. The standard solution was made by
dissolving 7.3 mg of DM standard in water diluted to a volume of 100 mL. The concentration of
the standard was 0.073 mg/mL. The samples used in the final trial were prepared more dilute
than the original samples in order to further avoid interference. In trial 1, we could only see a
peak near 360 nm. In trial 2, we could see a peak near 322 nm. Further dilution of the lozenge
solution allowed us to see the fluorescence peak of DM near 309.418 ± 2.733 nm in trial 4. We
concluded that this dilution was the best due to the proximity of the fluorescence peak near the
fluorescence peak of DM near 305 to 312 nm, found during the pre-experimental testing.

Preparation of Solutions for Analysis

In trials 1 – 3 we used the method of standard addition by adding the desired volume of
the lozenge solution directly to the cuvette followed by the desired volume of standard solution
while keeping the total volume at 3 mL. In each case, run 1 consisted of 3 mL of the lozenge
solution. Run 2 used 2.995 mL of the lozenge solution and 0.005 mL of the standard solution.
Run 3 used 2.990 mL of the lozenge solution and 0.010 mL of the standard solution. Runs 4 and
5 used 2.985 and 2.980 mL of the lozenge solution, respectively, and 0.015 and 0.020 mL of the
standard solution, respectively. We mixed the desired amounts of lozenge and standard solutions
in the cuvette using a transfer pipette. This method, however, produced some unexpected
fluctuations in the intensities measure. Due to the irregular trend produced by this method,
possibly due to the turbidity of the solution from the method of mixing, we reconsidered our
method of standard addition.

For trial 4, in a 10 mL volumetric flask, we added 3 mL of the approximately 0.01
mg/mL lozenge solution, added various amounts of the 0.073 mg/mL standard solution, and
diluted with deionized water to a final volume of 10 mL. The amounts used for each flask are
summarized in Table 1 below:

<table>
<thead>
<tr>
<th>Trial 4, Run No.</th>
<th>V_{lozenge} (mL)</th>
<th>V_{standard} (mL)</th>
<th>V_{total} (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0.25</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.50</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>0.75</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>1.00</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1. The amounts of lozenge solution and standard solution used in each flask for Trial 4. The flasks were
diluted to volume with deionized water.

Fluorescence Spectrophotometric Analysis

The Cary Eclipse Varian Fluorescence Spectrophotometer was used with the following
parameters: wavelength of excitation – 285 nm; range of wavelengths – 295 to 400 nm;
excitation and emission slit widths – 5 nm; medium scan speed; and high voltage. These
parameters were used unchanged for trials 1 and 2. However, we decreased the excitation slit
width to 2.5 nm in trials 3 and 4 due to the flooding of light experienced by the more dilute
samples. We obtained two measurements for each run in all trials.
Data Analysis and Results

For all trials, the standard addition calibration curve was made by plotting the intensities of each run versus $C_{\text{standard}}(V_{\text{spike}}/V_{\text{total}})$ for each run. A trend-line was obtained in the form of $y=mx+b$. The concentration of the lozenge solution was determined by finding the x-intercept which is equal to $-b/m$ and $-C_{\text{lozenge}}(V_{\text{lozenge}}/V_{\text{total}})$. The concentration of the lozenge solution was then isolated. This concentration was then be compared to the concentration as stated on the box of Chloraseptic Total cough drops.

Trials 1 – 2 produced a concentration values near 0.008 mg/mL, which is much lower than the reported value. Trial 3 had such an irregular trend that it was not used to calculate the concentration of the lozenge solution. Trial 4 produced the most reliable data, shown in Table 2. The average values of these measurements was used to make the calibration curve shown in Figure 1.

<table>
<thead>
<tr>
<th>Trial 4, Run No.</th>
<th>Replicate Measurement</th>
<th>Fluorescence Peak Wavelength (nm)</th>
<th>Intensity (a.u.)</th>
<th>Avg. Intensity (a.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI Water Blank</td>
<td>1</td>
<td>no intensity above threshold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>340.159</td>
<td>340.159</td>
<td>339.201</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>338.243</td>
<td>338.243</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>523.562</td>
<td>523.562</td>
<td>522.502</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>521.442</td>
<td>521.442</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>647.527</td>
<td>647.527</td>
<td>647.667</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>647.807</td>
<td>647.807</td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>870.543</td>
<td>870.543</td>
<td>876.624</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>882.705</td>
<td>882.705</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1000</td>
<td>1000</td>
<td>1000.000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1000</td>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Raw data obtained from Trial 4. Run 5 peaked out of range of the detector for a range of 7 nm where the true peak was located.

![Standard Addition Calibration of Chloraseptic Total cough drops](image_url)

Figure 1. The standard addition calibration curve from Trial 4.
The linear regression for this plot produces equation (1). The corresponding fit to this equation is shown in equation (2). The concentration of the lozenge was found by equations (3) and (4), which utilize the x-intercept of the calibration curve:

\[ y = 91820x + 342.05 \]  
\[ I_{1+x} = \varepsilon l C_{\text{stand}} \left( \frac{V_{\text{stand}}}{V_{\text{total}}} \right) + \varepsilon l C_{l} \left( \frac{V_{l}}{V_{\text{total}}} \right) \]  
\[ -\frac{b}{m} = C_{l} \frac{V_{l}}{V_{\text{total}}} \]  
\[ C_{l} = \frac{b}{m} \frac{V_{\text{total}}}{V_{l}} = \frac{342.05 \times 10}{91820 \times 3} = 0.0124 \text{ mg/mL} \]

The concentration of the lozenge solution was calculated to be 0.0124 mg/mL. Since one cough drop was diluted in a 500 mL volumetric flask, the cough drop would have to contain 6.2 mg of DM. Comparatively, the label for Chloraseptic Total stated that each drop contained 5 mg of DM, which would be 0.01 mg/mL when one cough drop is dissolved in a 500 mL solution. The percent difference between the experimental value, 6.2 mg DM, and the reported value, 5 mg DM, is 21.43%.

\[ \square \]

Conclusion

As seen in previous experiments, the method of standard addition is a reliable method of analyzing samples of unknown concentration or verifying the concentration of a sample, as seen in this experiment. Furthermore, this experiment showed the utility of fluorescence spectroscopy when analyzing an aromatic compound, such as dextromethorphan hydrobromide monohydrate. The concentration of DM in a Chloraseptic Total cough drop was found to be 6.2 mg, which is a 21.43% difference from the reported 5 mg of DM in each lozenge.

In addition to obtaining the desired result, this experiment allowed us to draw several conclusions. First, it is important to let any samples to be measured using fluorescence spectrophotometric analysis to fully homogenize before the analysis. Before Trial 4, we prepared the 10 mL samples on March 25, 2014, and let the solutions sit for one day before use on March 27, 2014. This produced more consistent results than the other trials. Secondly, for solutions in which quenching and other types of interference could be a hindrance, very dilute solutions are desirable for analysis. When we compared our results between the different trials, the interference shown at 350 nm decreased significantly and was eventually overshadowed by the fluorescence at 309 nm as the lozenge solution was diluted more. Now that a reliable method of analyzing DM has been found, this experiment can now be repeated more carefully to obtain an even more quantitatively accurate value.
References

A. **College, Department and Date**

1. College: *Arts and Sciences: Main Campus*
2. Department: *Chemistry and Chemical Biology*
3. Date: 1/15/09

B. **Academic Program of Study**

M.S. Chemistry

C. **Contact Person(s) for the Assessment Plan**

Alisha Ray, Lecturer II, adray@unm.edu

D. **Broad Program Goals & Measurable Student Learning Outcomes**

Graduate Program Goals and Student Learning Outcomes

Upon graduating from the graduate program, students will:

1. Develop a broad understanding of the major areas of chemistry with an understanding and awareness of the professional, ethical and safe applications of their knowledge.
   a. Possess broad factual knowledge at an advanced level in multiple areas of chemistry
   b. Actively participate in the weekly departmental seminars
2. Acquire a significant and deep-rooted knowledge in their chosen sub-discipline in chemistry.
   a. Learn subject specific content such as synthesis and characterization, reaction mechanisms, thermodynamics, quantum mechanics, kinetics, spectroscopy, equilibrium and quantitative methods
   b. Attend divisional student seminars in their chosen area of chemistry
3. Report, present and/or publish the results of their research and independently solve research problems.
   a. Present independently researched topics in their divisional seminar
   b. Publish their research findings in peer reviewed scientific journals with their research advisor(s)
   c. Write a coherent masters thesis or written final project covering their specific contributions to the discipline of chemistry
4. Be prepared for entry into academe or industry.
   a. Be members of at least one professional scientific organization
   b. Engage in collaborative research with other scientists in their field
   c. Solve research problems independently or as a small team
Future goal to be developed: Students will have the knowledge, skills and ability to define and study a specific research project and apply appropriate scientific methods to it.

E. Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes annually and to measure all priority program outcomes at least once over two consecutive three-year review cycles. Describe below the plan for the next three years of assessment of program-level student learning outcomes.

1. Student Learning Outcomes

Relationship to UNM Student Learning Goals (insert the program SLOs and check all that apply):

<table>
<thead>
<tr>
<th>University of New Mexico Student Learning Goals</th>
<th>Knowledge</th>
<th>Skills</th>
<th>Responsibility</th>
<th>Program SLO is conceptually different from university goals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program SLOs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a. Learn subject specific content such as synthesis and characterization, reaction mechanisms, thermodynamics, kinetics, spectroscopy, equilibrium and quantitative methods.</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3b. Publish their research findings in peer reviewed scientific journals with their research advisor(s).</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3c. Write a coherent masters thesis or written final project covering their specific contributions to the discipline of chemistry</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

2. How will learning outcomes be assessed?

A. What:

i. SLO 2a will be measured using one or two questions from the cumulative examinations (written by faculty) given eight times each academic year. M.S. degree students must pass three exams within fourteen attempts.

SLO 3b will be measured by having graduate advisors submit a list of the work published each year involving their graduate students. Evidence for SLO 3c will be gathered from final project committee members using the Report on Thesis or Dissertation provided by the Office of Graduate Studies (see attachment).

ii. All SLOs will be measured directly.

iii. The program’s performance target for SLO 2a is for one-third of the students (those students who are required to take the exam) to perform acceptably on the chosen cumulative exam question(s). The target for SLO 3b is to have 50% of the students in the program to have their research published in a peer reviewed journal each year.
The expected target is for SLO 3c is that 75% of students giving a final project defense each year pass without needing extensive written revisions.

B. **Who**: Evidence from each student in the M.S. program will be sampled over a three year cycle.

3. **When will learning outcomes be assessed? When and in what forum will the results of the assessment be discussed?**

   Data collected for SLOs 2a, 3b, and 3c in fall 2008 and spring of 2009 will be included in the program pilot assessment. Interpretation and discussion of the same SLOs will be completed by mid June 2009. Data collected in the summer of 2009, fall 2009 and spring 2010 over the same SLOs will be interpreted and discussed at the fall faculty retreat in August 2010. A similar pattern will follow for the next academic year.

4. **What is the unit’s process to analyze/interpret assessment data and use results to improve student learning?**

   1. The chair of the assessment committee will be the faculty member responsible for collecting evidence during the academic year will be included one or two other faculty members on the committee to analyze and interpret the assessment data.
   2. The implications of the assessment will be discussed at a meeting in April each year.
   3. Recommendations will be compiled by the assessment committee chair and communicated in writing to the department Chair by May 15th each year. Copies of the document will be provided and discussed in the annual faculty retreat each August.
Academic Program
Plan for Assessment of Student Learning Outcomes
The University of New Mexico

A. College, Department and Date

1. College: Arts and Sciences: Main Campus
2. Department: Chemistry and Chemical Biology
3. Date: 6/15/08

B. Academic Program of Study
Ph.D. Chemistry

C. Contact Person(s) for the Assessment Plan
Alisha Ray, Lecturer II, adray@unm.edu

D. Broad Program Goals & Measurable Student Learning Outcomes

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3. Report, present and/or publish the results of their research and independently solve research problems.
   a. Present independently researched topics in their divisional seminar
   b. Publish their research findings in peer reviewed scientific journals with their research advisor(s)
   c. Independently solve research problems
   d. Critically analyze their own results and the results of others, including published literature
   e. Prepare, present and publically defend their research project at a formal research proposal (RP) and dissertation defense.
   f. Write a coherent dissertation covering their specific contributions to the discipline of chemistry
4. Be prepared for entry into academe or industry.
a. Be members of at least one professional scientific organization
b. Engage in collaborative research with other scientists in their field
c. Solve research problems independently or as a small team

Future goal to be developed: Students will have the knowledge, skills and ability to define and study a specific research project and apply appropriate scientific methods to it.

E. Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes annually and to measure all priority program outcomes at least once over two consecutive three-year review cycles. Describe below the plan for the next three years of assessment of program-level student learning outcomes.

1. Student Learning Outcomes

Relationship to UNM Student Learning Goals (insert the program SLOs and check all that apply):

<table>
<thead>
<tr>
<th>University of New Mexico Student Learning Goals</th>
<th>Program SLOs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knowledge</td>
</tr>
<tr>
<td>2a. Learn subject specific content such as synthesis and characterization, reaction mechanisms, thermodynamics, kinetics, spectroscopy, equilibrium and quantitative methods.</td>
<td>X</td>
</tr>
<tr>
<td>3b. Publish their research findings in peer reviewed scientific journals with their research advisor(s).</td>
<td>X</td>
</tr>
<tr>
<td>3d. Write a coherent dissertation thesis covering their specific contributions to the discipline of chemistry</td>
<td>X</td>
</tr>
</tbody>
</table>

2. How will learning outcomes be assessed?

A. What:

i. SLO 2a will be measured using one or two cumulative examination questions (written by faculty) that are given eight times each academic year. SLO 3b will be measured by having graduate advisors submit a list of the work published each year involving their graduate students. Evidence for SLO 3d will be gathered from the dissertation committee members using the Report on Thesis or Dissertation provided by the Office of Graduate Studies (see attachment).

ii. SLO 2a will be measured directly and SLOs 3b, and 3d will be measured indirectly.

iii. The program’s performance target for SLO 2a is for one-third of the students (those students who are required to take the exam) to perform acceptably on the chosen
cumulative examination question(s). The target for SLO 3b is to have 50% of the students in the program to have their research published in a peer reviewed journal each year. Lastly, it is expected for SLO 3d that 75% of students giving a research proposal or dissertation defense each year pass without needing extensive written revisions.

B. **Who**: Evidence from each student in the Ph.D. program will be sampled over a three year cycle.

3. **When will learning outcomes be assessed? When and in what forum will the results of the assessment be discussed?**

Data collected for SLOs 2a, 3b, and 3d in fall 2008 and spring of 2009 will be included in the program pilot assessment. Interpretation and discussion of the same SLOs will be completed by mid June 2009. Data collected in the summer of 2009, fall 2009 and spring 2010 over the same SLOs will be interpreted and discussed at the fall faculty retreat in August 2010. A similar pattern will follow for the next academic year.

4. **What is the unit’s process to analyze/interpret assessment data and use results to improve student learning?**

1. The chair of the assessment committee will be the faculty member responsible for collecting evidence during the academic year will be included one or two other faculty members on the committee to analyze and interpret the assessment data.
2. The implications of the assessment will be discussed at a meeting in April each year.
3. Recommendations will be compiled by the assessment committee chair and communicated in writing to the department Chair by May 15th each year. Copies of the document will be provided and discussed in the annual faculty retreat each August.
Instructions
UNM Academic Programs/Unit Combined Assessment Plan and Report Template
The University of New Mexico

Instructions: This assessment plan and report template guides the creation of three-year assessment plans that will be used to assess academic student learning outcomes as well as assists with the reporting of the assessment of student learning outcomes for academic degree and certificate programs at UNM. If you have any questions about either the plan or the report templates, please contact the Office of Assessment at assess@unm.edu or (505) 277-4130.

Note: While developing the plan, consider that not every SLO needs to be assessed every year; however, over a three-year period, every SLO should be assessed.

• Assessment plans should include clear differentiations between degrees (i.e., certificate, bachelor, master’s, and/or doctoral).
• Assessment plans should be reviewed and approved at the college/school/branch level by the College Assessment Review Committee (CARC) or equivalent.

Overview: The template is divided into three parts:
Part I: Cover Page (Page 3)
Part 1 of the template serves as the cover page. Please provide all of the information requested for the cover page.

Part II: Assessment PLAN (Pages 4-8)
The second part of the template requests information on the student learning outcomes, program’s goal(s), UNM Student Learning Goals, assessment measures, performance benchmarks, and student population(s) within the table. It is followed by a narrative section that contains four questions that inquire about the assessment artifact, the SLO review schedule, plans to review and analyze the data, and how the results will be distributed.

Part III: Assessment REPORT (Pages 9-13)
The first section of Part III requires a narrative response about last year’s assessment report, the changes implemented, and the revisions to the assessment process that were generated. The following section is a table that requires the user to copy and paste the SLOs (from the already-completed PLAN), that were assessed this year. The table requests a description of the actual student population that was used, and results. The third part of the REPORT template is a narrative section that contains four questions that inquire about participation, data analysis, recommendations, and distribution of information.
Part I: Cover Page
UNM Academic Programs/Unit Combined Assessment Plan and Report Template
The University of New Mexico

College, Department and Date:

College/School/Branch Campus: CAS
Department: Chemistry & Chemical Biology
Date: November 15, 2016
Active Plan Years (select the three year cycle that applies):

☐ AY16/17-18/19  ☐ AY17/18-19/20  ☐ AY18/19-20/21  ☑ AY19/20-21/22

Academic Program of Study:*

Degree or Certificate level: B.A.  Name of the program: B.A. Chemistry

Note: Academic Program of Study is defined as an approved course of study leading to a certificate or degree reflected on a UNM transcript. A graduate-level program of study typically includes a capstone experience (e.g. thesis, dissertation, professional paper or project, comprehensive exam, etc.).

Contact Person(s) for the Assessment Plan (include at least one name, title and email address):

● K. Joseph Ho, Dir of Chemical Education, Associate Chair, khoj@unm.edu

Dean / Associate Dean / CARC Approval Signature:
Part II: Assessment PLAN
UNM Academic Programs/Unit Combined Assessment Plan and Report Template
The University of New Mexico

Please identify at least one of your program goals:

Program Goal #1: Content Mastery: Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry
Program Goal #2: Communication Skills: Convincingly present scientific data and arguments in an oral and written format
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Need help formulating your Program Goals? Click here for additional information provided by the UNM Office of Assessment and Academic Program Review.
Please use the grid below to align your program goals to your student learning outcomes and assessment plans:

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<tr>
<th>Student Learning Outcomes (SLOs)</th>
<th>Program Goal #</th>
<th>UNM Student Learning Goals</th>
<th>Assessment Measures</th>
<th>Performance Benchmark</th>
<th>Student Population(s)</th>
</tr>
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<tbody>
<tr>
<td>For each row in the table, provide a SLO. If needed, add more rows. A SLO may be targeted by or aligned with more than one program goal. If a program awards more than one degree (i.e., B.S., M.A. etc.), the SLOs for graduate and undergraduate must be different. Graduate degree SLOs must be different (Master ≠ Doctorate). For additional guidance on SLOs, click here.</td>
<td>Please list the Program Goal(s) that the SLOs are aligned under. Use the numbering system (1,2,3..) assigned above.</td>
<td>Check as appropriate: K=Knowledge; S=Skills; R=Responsibility</td>
<td>Provide a description of the assessment instrument used to measure the SLO. For additional guidance on assessment measures, click here.</td>
<td>What is the program’s benchmark (quantitative goal/criteria of success for each given assessment measure)? State the program’s “criteria for success” or performance benchmark target for successfully meeting the SLO (i.e., At least 70% of the students will pass the assessment with a score of 70 or higher.)</td>
<td>Describe the sampled population, including the total number of students and classes assessed. See note below.</td>
</tr>
<tr>
<td><strong>Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises.</strong></td>
<td>1</td>
<td>✔ ✔ ☐</td>
<td>Each SLO will be measured using samples of evidence of learning from courses: CHEM 315, 421/425, 253L, 124L, 452, 304L</td>
<td>The program’s assessment target is to have at least 60% of the students in the B.A. program to perform satisfactorily or better. Scoring rubrics will be used for some measures, designed by the faculty member who analyzes the data, and explained in the annual reports.</td>
<td>All students would be included in the assessment of a service course without separating majors from the analysis with the assumption that a large sample can represent a small subset.</td>
</tr>
<tr>
<td><strong>Be able to employ critical thinking to solve problems using multiple layers of data analysis</strong></td>
<td>1</td>
<td>✔ ✔ ☐</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td><strong>Organize and represent experimental data using appropriate methods (spreadsheets, etc)</strong></td>
<td>2</td>
<td>✔ ✔ ☐</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Task</td>
<td>Level</td>
<td>Completed</td>
<td>Notes</td>
<td>Level</td>
<td>Completed</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>-------</td>
<td>-----------</td>
<td>-------</td>
<td>-------</td>
<td>-----------</td>
</tr>
<tr>
<td>Write coherent scientific reports</td>
<td>2</td>
<td>✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have a working knowledge of basic laboratory safety</td>
<td>3</td>
<td>✔ ✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate scientific literacy</td>
<td>3</td>
<td>✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have general skills to work in small groups to accomplish scientific projects</td>
<td>3</td>
<td>✔ ✔ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE: State explicitly whether the program’s assessment will include evidence from all students in the program or a sample (by student, by course section, by milestone). When possible, it is best to study the entire population of students in your program. However, in larger programs it may be more pragmatic to study a sample of the students instead. If sampling, please describe the course sections and/or the milestones. If you have questions about appropriate sampling, please contact your unit’s assessment representative or the Office of Assessment at assess@unm.edu or (505) 277-4130.

Please use the area below to elaborate on your assessment plans.

Assessing and analyzing student learning outcomes:

a. Please describe the student artifact/performance that you will use to gather your assessment data?
   - Exam questions: selected questions or the entire exams could be used as a direct measure for certain SLO.
   - Lab reports: In lab courses, student lab reports graded with a rubric could be used as a direct measure for certain SLOs.
   - Presentation: In some courses, students are required to give presentations. The grades of these presentation can be used as a direct measure of certain SLOs. A rubric will be used for grading.
   - Quiz questions: In some courses, quizzes are administered. The grades of these quizzes can be used as a direct measure for certain SLOs.
   - Exit surveys for graduates: Every graduate from the program is offered an exit survey. We use the result of the exit surveys as an indirect measure for certain SLOs.
   - Homework: individual assignment or the average can be used for assessing student’s SLOs as a direct measure. The interpretation of the result of homework should be used with the discussion of condition.

b. Does your program assess all SLOs every year, or are they assessed on a staggered, three-year cycle? If staggered, please describe which SLOs will be assessed for each year. If a table better describes your response, insert it here. Staggered over three years. Please see the Table below for the three-year plan starting year 2019-2020.

<table>
<thead>
<tr>
<th>Goal/SLO</th>
<th>Year 1: Courses to be assessed</th>
<th>Year 2: Courses to be assessed</th>
<th>Year 3: Courses to be assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Content Mastery: Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry</td>
<td>A1. CHEM 302 Exit interview</td>
<td>A1. Exit interview CHEM 315</td>
<td></td>
</tr>
<tr>
<td>1. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises. (NM HED Area III: 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Be able to employ critical thinking to solve problems using multiple layers of data analysis (NM HED Area III: 2, 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### B. Communication Skills: Convincingly present scientific data and arguments in an oral and written format

1. Organize and represent experimental data using appropriate methods (spreadsheets, etc) *(NM HED Area III: 1, 2, 4)*
2. Write coherent scientific reports *(NM HED Area III: 3)*

|--------------------------------|--------------------------------|-------------------|

### C. Professional Development: Be prepared for entry into professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.

1. Have a working knowledge of basic laboratory safety *(NM HED Area III: 5)*
2. Demonstrate scientific literacy *(NM HED Area III: 3, 5)*
3. Have general skills to work in small groups to accomplish scientific projects *(NM HED Area III: 5)*

| C1. CHEM 1225L Exit interview | C2. CHEM 452 Exit interview | C3. CHEM 304L Exit interview |
c. What is the process you will use to review, analyze and interpret your assessment data?

Priority SLOs will be measured by at least one semester’s performance. The number of priority SLOs measured each year may vary between one and three SLOs. The results of the outcomes measured the previous fall will be discussed each August by an Assessment Committee. All department faculty will be notified via email and invited to the meeting no less than a week before the scheduled meeting. The faculty collecting evidence (data) during that academic year from the selected courses for pre-identified SLOs.

d. What is the process you will use to communicate and implement your assessment results?

- The report will be summarized and distributed to all faculty members.
- The report will be scheduled for discussion in January’s faculty meeting
- The report will be discussed with Teaching Assistants for individual courses during the pre-semester training.
In response to last year’s assessment report, please:

a. Describe the program changes that were implemented.

There were no changes for the B.A. program recommended by last year’s report. All SLOs assessed last year met benchmarks and we satisfied with the results.

b. Describe any revisions to your assessment process that were made for this reporting cycle.

<table>
<thead>
<tr>
<th>Goal/SLO</th>
<th>Year 2019-20: Courses to be</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. <strong>Content Mastery:</strong> Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry</td>
<td>CHEM 302</td>
</tr>
<tr>
<td>1. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises.</td>
<td></td>
</tr>
<tr>
<td>B. <strong>Communication Skills:</strong> Convincingly present scientific data and arguments in an oral and written format</td>
<td>CHEM 2310C</td>
</tr>
<tr>
<td>1. Organize and represent experimental data using appropriate methods (spreadsheets, etc)</td>
<td></td>
</tr>
<tr>
<td>C. <strong>Professional Development:</strong> Be prepared for entry into professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.</td>
<td>CHEM 304L</td>
</tr>
<tr>
<td>1. Have a working knowledge of basic laboratory safety</td>
<td></td>
</tr>
</tbody>
</table>

- There is only one student in chemistry from CHEM 1225L from either the fall 19 or spring 20 semester. Due to insufficient data, we did not use CHEM 1225L for SLO C1. Data collected from CHEM 304L were used instead.

Please use the grid and narrative responses below to discuss your assessment results from this year:
<table>
<thead>
<tr>
<th>SLOs (from PLAN above)</th>
<th>Student Population</th>
<th>Results*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SLOs are from your entries in the PLAN above that were measured during this year:</strong></td>
<td><strong>Describe the sampled population, including the total number of students and classes assessed.</strong></td>
<td>State whether the performance benchmark was met, not met, or exceeded AND the total number of students assessed (i.e., Exceeded, 95 out of 111 (86%) students)</td>
</tr>
<tr>
<td>Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises.</td>
<td>9 Chemistry majors from CHEM 302-001 and 004 3 Chemistry majors from the exit interview</td>
<td>Direct measure: The homework grade averages of 9 Chemistry majors were higher than the class averages on all but two of the assignments (15 total). The Chemistry majors earned very close to the same average as the entire class on the rest of the homework assignments, and only lower on one. All nine Chemistry majors (100%) met the benchmark.</td>
</tr>
<tr>
<td>Organize and represent experimental data using appropriate methods (spreadsheets, etc.)</td>
<td>20 Chemistry majors from CHEM 2310C (7 from the fall semester and 13 from the spring semester)</td>
<td>Direct measure: 65% of 20 (13 out of 20) students met the benchmark of 70% average from the data analysis. The mean grades of data analysis for these chemistry majors is 68.3%.</td>
</tr>
<tr>
<td>Have a working knowledge of basic laboratory safety</td>
<td>6 chemistry majors from CHEM 304L safety quiz</td>
<td>Direct measure: All students in Chemistry 304L in Fall 2019 were asked to complete a safety survey administered in UNM Learn before checking out of the laboratory at the end of the semester. This was a 15-question multiple choice survey that students were free to take at any time and under no time pressure. Students who scored above 70% on the safety survey were considered to have a working knowledge of laboratory safety. Out of the 6 BA Chemistry majors, 3 did not take the survey and 3 did. It can be inferred that the 3 students did pass 70% benchmark based on the data of all questions (next section).</td>
</tr>
</tbody>
</table>
NOTE: An asterisk (*) denotes that relevant data/evidence must be included for that column (refer to the “Annual Assessment Cycle Process” diagram for guidance). Evidence associated with program improvements/changes that are actually made or implemented have to be provided the next academic year/assessment period.
Please use the area below to elaborate on your findings.

*From data collected for the three areas of SLOs assessed this year, all areas had at least 80% met the benchmark set by the assessment plan. This result shows a continuous satisfactory performance of the B.A. students during 2018-2019 academic year.*

Please identify the SLOs that did not meet your benchmark defined in the Assessment Plan. Elaborate on what you think contributed to this:

*We do not have any SLOs that did not meet the benchmarks with a high mark.*

**In response to this assessment report, please answer the following questions:**

a. Who participated in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations)?
   - Faculty members taught the courses collected assessment data.
   - Undergraduate Program Committee members analyzed and interpreted the assessment data.
   - The exit interviews were given online and analyzed and interpreted by the Undergraduate Program Committee.
   - The recommendations were made by all faculty members of the Department and summarized by the Undergraduate Program Committee.

b. Data Analysis: Describe strengths and/or weaknesses of each SLO in students’ learning/performance based on the data results you provided in the table above (e.g., Even though the benchmark was met, 40% of the students struggled with Topic X ...).

   **Content mastery:** 100% of the chemistry majors from the CHEM 302 met the benchmark for the SLO based on homework grades. Comparing the mean of each homework from Chemistry majors to that of the class, the Chemistry majors scored higher averages than that of the entire class on all assignments except one. All averages were above 70%. Based on the result of our direct measure using homework, we are confident that our majors have good mastery of undergraduate organic chemistry.

   **Communication skill:** 92.3% of the chemistry majors from the spring semester of 2020 met the benchmark of report writing. The reports were graded with a rubric. The only student who did not meet the benchmark had dropped from the course.

   **Lab safety:** Because the Lab Safety Survey is not a graded assignment, there are no scores to analyze for the 3 B.A. students who did take it. However, it can be inferred that the 3 students did pass based on the data presented below:

   Question 1: 82% correct, Question 2: 98% correct, Question 3: 100% correct, Question 4: 78% correct, Question 5: 100% correct, Question 6: 100% correct, Question 7: 100% correct, Question 8: 100% correct, Question 9: 100% correct, Question 10: 93% correct, Question 11: 99% correct, Question 12: 97% correct, Question 13: 99% correct, Question 14: 100% correct, Question 15: 99% correct
c. Recommendations for Improvements/Changes:

- Describe any program changes (e.g., curriculum, instruction, etc.) that will be implemented.

  
  From the results of this year’s assessment, there is no change recommended for Chemistry B.A. program. However, the Department would ramp up the recruitment for Chemistry majors.

- Describe any revisions to your assessment process that will be made for the next reporting cycle.

  Because of the departure of a faculty member who teaches CHEM 452, we will not offer CHEM 452 next year and will collect data for evaluating SLO C2 from CHEM 421 instead. The next year’s assessment plan is list below:

<table>
<thead>
<tr>
<th>Goal/SLO</th>
<th>Year 2: Courses to be assessed</th>
</tr>
</thead>
</table>
| **B. Content Mastery:** Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry  
  2. Be able to employ critical thinking to solve problems using multiple layers of data analysis (NM HED Area III: 2, 4) | A2. CHEM 301 Exit interview |
| **C. Communication Skills:** Convincingly present scientific data and arguments in an oral and written format  
  2. Write coherent scientific reports (NM HED Area III: 3) | B2. CHEM 2310C Exit interview |
| **D. Professional Development:** Be prepared for entry into professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.  
  2. Demonstrate scientific literacy (NM HED Area III: 3, 5) | C2. CHEM 421 Exit interview |
d. How, when, and to whom will results and recommendations be communicated?

The report will be summarized and distributed to all faculty of the Department through email and monthly faculty meetings in the spring semester of 2021. Graduate TAs will be explained with the recommendations as a reference for their teaching.
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The University of New Mexico

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Note: While developing the plan, consider that not every SLO needs to be assessed every year; however, over a three-year period, every SLO should be assessed.

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The University of New Mexico

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Date: November 15, 2020
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☐ AY16/17-18/19  ☐ AY17/18-19/20  ☐ AY18/19-20/21  × AY19/20-21/22

Academic Program of Study:* 

Degree or Certificate level: B.S. Name of the program: B.S. Chemistry

Note: Academic Program of Study is defined as an approved course of study leading to a certificate or degree reflected on a UNM transcript. A graduate-level program of study typically includes a capstone experience (e.g. thesis, dissertation, professional paper or project, comprehensive exam, etc.).

Contact Person(s) for the Assessment Plan (include at least one name, title and email address):

• K. Joseph Ho, Dir of Chemical Education, Associate Chair, khoj@unm.edu

Dean / Associate Dean / CARC Approval Signature:
Part II: Assessment PLAN
UNM Academic Programs/Unit Combined Assessment Plan and Report Template
The University of New Mexico

Please identify at least one of your program goals:

Program Goal #1: Content Mastery: Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry
Program Goal #2: Laboratory Skills: Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods format
Program Goal #3: Communication Skills: Convincingly present scientific data and arguments in an oral and written format
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<tr>
<td></td>
<td>Construct and test hypotheses</td>
<td>2</td>
<td>&quot;</td>
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<tr>
<td>Activity</td>
<td>MS</td>
<td>CW</td>
<td>IS</td>
<td>OTHER</td>
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<td>-------------------------------------------------------------------------</td>
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<tr>
<td>Design experiments</td>
<td>2</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use instrumentation to collect data</td>
<td>2</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process data using a computer and use statistics to evaluate data</td>
<td>2</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
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</tr>
<tr>
<td>Have a working knowledge of basic chemical safety</td>
<td>2</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Interpret experimental results and draw conclusions</td>
<td>2</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
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</tr>
<tr>
<td>Task</td>
<td>Level</td>
<td>Criterion 1</td>
<td>Criterion 2</td>
<td>Criterion 3</td>
<td>Criterion 4</td>
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<td>----------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Organize and represent experimental data using appropriate methods (spreadsheets, etc)</td>
<td>3</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write coherent scientific reports</td>
<td>3</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have a working knowledge of basic laboratory safety</td>
<td>3</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Demonstrate scientific literacy</td>
<td>4</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Have general skills to work in small groups to accomplish scientific projects</td>
<td>4</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE: State explicitly whether the program’s assessment will include evidence from all students in the program or a sample (by student, by course section, by milestone). When possible, it is best to study the entire population of students in your program. However, in larger programs it may be more pragmatic to study a sample of the students instead. If sampling, please describe the course sections and/or the milestones. If you have questions about appropriate sampling, please contact your unit’s assessment representative or the Office of Assessment at assess@unm.edu or (505) 277-4130.

Please use the area below to elaborate on your assessment plans.

Assessing and analyzing student learning outcomes:

a. Please describe the student artifact/performance that you will use to gather your assessment data?

   From CHEM 311 and 312, homework grades and grades from questions 6 and 9 of the final exam were collected. From CHEM 453L, in-lab performance grades and lab report grades were collected. The exit surveys were given to graduates online and collected online for analysis.

b. Does your program assess all SLOs every year, or are they assessed on a staggered, three-year cycle? If staggered, please describe which SLOs will be assessed for each year. If a table better describes your response, insert it here.

<table>
<thead>
<tr>
<th>SLO</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Content Mastery:</strong> Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry</td>
<td>A1. 311/312 Exit interview</td>
<td>A2. CHEM 421/425 Exit interview</td>
<td>A1. 431 Exit interview</td>
</tr>
<tr>
<td></td>
<td>1. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Be able to employ critical thinking to solve problems using multiple layers of data analysis</td>
<td></td>
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</tr>
<tr>
<td><strong>B. Lab Skills:</strong> Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods</td>
<td>B4. CHEM 2230L Exit interview</td>
<td>B1. CHEM 1225L Exit interview</td>
<td>B2. CHEM 453L</td>
</tr>
<tr>
<td></td>
<td>1. Construct and test hypotheses</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Design experiments</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Use instrumentation to collect data</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Process data using a computer and use statistics to</td>
<td></td>
<td></td>
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<tr>
<td>C. <strong>Communication Skills</strong>: Convincingly present scientific data and arguments in an oral and written format</td>
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<td></td>
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</tr>
<tr>
<td>1. Organize and represent experimental data using appropriate methods (spreadsheets, etc)</td>
<td></td>
<td></td>
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<tr>
<td>2. Write coherent scientific reports</td>
<td></td>
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</tr>
<tr>
<td>3. Present scientific ideas and arguments in a professional setting</td>
<td></td>
<td></td>
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<tr>
<td>D. <strong>Professional Development</strong>: Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.</td>
<td></td>
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</tr>
<tr>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Have general skills to work in small groups to accomplish scientific projects</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>C.</th>
<th>Communication Skills</th>
<th>C3. CHEM 432L CHEM 453L Exit interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.</td>
<td>Professional Development</td>
<td>D1. CHEM 425/421 Exit interview</td>
</tr>
</tbody>
</table>

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**c. What is the process you will use to review, analyze and interpret your assessment data?**

1. **Priority SLOs will be measured by at least one semester’s performance. The number of priority SLOs measured each year may vary between one and three SLOs. The results of the outcomes measured the previous year were discussed each August by an Assessment Committee. All department faculty will be notified via email and invited to the meeting no less than a week before the scheduled meeting.**

2. **The faculty collecting evidence during that academic year**

---

**d. What is the process you will use to communicate and implement your assessment results?**

*The assessment reports were distributed to all faculty members through email and feedback were collected. The report was also explained and discussed to all TAs in the TA pre-semester training. The report will be scheduled to discuss in January’s faculty meeting The report will be discussed with Teaching Assistants for individual courses during the pre-semester training.*
In response to last year's assessment report, please:

a. Describe the program changes that were implemented.
   
   Last year, faculty recommended increasing course-based research experience (CURE) in the instruction to foster better lab skills. In response to the recommendation and the unexpected COVID-19 disruption, we have added CURE in both semesters of CHEM 1215L and 1225L and converted these labs into two different formats to accommodate different students’ needs based on their personal situation due to COVID-19 pandemic. The second half of the spring semester was instructed as remote scheduled. During this difficult time, many faculty members had participated in training for online instruction. Four faculty members has been selected by two Federal-funded projects in ECURE and SEP to implement CURE in our general chemistry courses. The recommended changes were discussed in the TA training before the Fall semester of 2019 (8/10-13). The recommended changes were integrated into the teaching CHEM 1215L.

b. Describe any revisions to your assessment process that were made for this reporting cycle.
   
   For this year, we followed the year-one plan listed below without a modification that B5 was not evaluated because of the COVID-19 lock-down and data was not collected from CHEM 432L. We still have 4 SLOs and 4 Goals being evaluated. The exit interview was not implemented because of the COVID-19 restriction which resulted in a cancellation of the Departmental Convocation.

<table>
<thead>
<tr>
<th>SLO</th>
<th>Year 1:</th>
</tr>
</thead>
</table>
| **A. Content Mastery:** Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry | • 311/312  
• Exit interview |
| 3. Apply their understanding of atomic theory, molecular structure and bonding, thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on examinations and laboratory exercises |  |
| **B. Lab Skills:** Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods | • CHEM 2310C  
• Exit interview |
| 4. Process data using a computer and use statistics to evaluate data |  |
| **C. Communication Skills:** Convincingly present scientific data and arguments in an oral and written format | • CHEM 453L  
• Exit interview |
| 3. Present scientific ideas and arguments in a professional setting |  |
| **D. Professional Development:** Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service. | • CHEM 425/421  
• Exit interview |
| 3. Demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry |  |
Please use the grid and narrative responses below to discuss your assessment results from this year:

<table>
<thead>
<tr>
<th>SLOs (from PLAN above)</th>
<th>Student Population</th>
<th>Results*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOs are from your entries in the PLAN above that were measured during this year:</td>
<td></td>
<td>State whether the performance benchmark was met, not met, or exceeded AND the total number of students assessed (i.e., Exceeded, 95 out of 111 (86%) students) For additional guidance on reporting results, click here.</td>
</tr>
<tr>
<td>A1. Apply their understanding of atomic theory, molecular structure and bonding,</td>
<td>11 Chemistry major students taking CHEM 311 from fall 2019 7 Chemistry major students taking CHEM 312 from spring 2020</td>
<td>70% of 11 B.S. students met the benchmark from the final grades of CHEM 311. For Chemistry 312, BS chemistry majors achieved 25 out of 28 possible passing scores (89%). For thermodynamics (E1 and E2) 12 of the 14 scores were passing (86%). For chemical kinetics (E3), 6 of 7 were passing (86%). All of the homework scores were passing (100%).</td>
</tr>
<tr>
<td>thermodynamics, kinetics, chemical reactions, spectroscopy and synthesis on</td>
<td></td>
<td></td>
</tr>
<tr>
<td>examinations and laboratory exercises.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4. Process data using a computer and use statistics to evaluate data</td>
<td>13 Chemistry major students taking CHEM 2310C in the fall 2019 and spring 2020.</td>
<td>We used the results of data analysis using computer students submitted for each experiment as the direct measure of this SLO. The mean of the performance of the whole class was 73%. The mean of the sample was 72.4%. There were 69.2% (9 out of 13) of the samples met the benchmark requirement of 70%.</td>
</tr>
<tr>
<td>C3. Present scientific ideas and arguments in a professional setting</td>
<td>13 B.S. students taking CHEM 453L in the spring 2020.</td>
<td>The mean of the individual presentation was 79.15%. There were 84.6% (11 out of 13) of the samples met the benchmark requirement of 70%.</td>
</tr>
<tr>
<td>D3. Demonstrate scientific literacy and be familiar with the status of current</td>
<td>5 B.S. students taking CHEM 425 in spring 2020.</td>
<td>The direct measure used exam II from the course which required them to demonstrate scientific literacy through recognizing and interpreting chemical structures. There were 80% of the major students scored greater than the benchmark of 70% on this exam.</td>
</tr>
<tr>
<td>research in the field of chemistry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE: An asterisk (*) denotes that relevant data/evidence must be included for that column (refer to the “Annual Assessment Cycle Process” diagram for guidance). Evidence associated with program improvements/changes that are actually made or implemented have to be provided the next academic year/assessment period.
Please use the area below to elaborate on your findings. Please identify the SLOs that did not meet your benchmark defined in the Assessment Plan. Elaborate on what you think contributed to this:

*All assessed SLOs met benchmark defined in the Assessment Plan.*

In response to this assessment report, please answer the following questions:

a. Who participated in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations)?

- Faculty members who taught the courses collected assessment data.
- Undergraduate Program Committee members analyzed and interpreted the assessment data
- The exit interviews were not implemented in May because of the COVID-19 restriction
- The recommendations were made by all faculty members of the Department and summarized by the Undergraduate Program Committee.

b. Data Analysis: Describe strengths and/or weaknesses of each SLO in students’ learning/performance based on the data results you provided in the table above (e.g., Even though the benchmark was met, 40% of the students struggled with Topic X ...).

**Content mastery:** The direct measure was implemented as Homework, Exams 1 and 2 were representative of thermodynamics, and Exam 3 of kinetics. These were core areas of physical chemistry that students were expected to understand. Scores of 70 or better (after curve adjustments) was considered a reasonable measure of proficiency in these subjects. The results for Chem 312 were for Spring 2020, the semester interrupted by coronavirus, so should not be taken as if from a normal semester. Exam three was remote and unproctored, essentially like a large homework assignment. Also, this particular group of B.S. chem majors was unusually strong. All-in-all, for this group, for this interrupted semester, the results seem more than adequate.

**Lab Skills:** The mean value of Chemistry majors (72.4%) from this year was statistically the same as the rest of the students (73%) in CHEM 2310C. The percentage of Chemistry majors met the benchmark (69.2%) was lower than last year’s, which is believed to be partially due to the COVID-19 pandemic that student’s learning was interrupted after the spring break. Another factor to be considered is the nature of the course we sampled our data from. CHEM 2310C is a precision-oriented course where grades were based on the accuracy and precision of students’ laboratory work. The precision work has been considered by students to be difficult to master which is reflected on the percentage met for the benchmark.

**Communication skills:** Students did well in this area with nearly 85% meeting the benchmark and a high average of near 80%. Two students did not meet the benchmark because of personal situation due to COVID-19 pandemic. Without considering these two students, all other students met the benchmark and did an excellent job in giving the scientific presentations.

**Professional development:** In this exam students were tested for their knowledge regarding enzyme reaction mechanisms for enzymes involved in central metabolism. The exam required them to demonstrate scientific literacy through recognizing and interpreting chemical
structures. The material covers the current understanding of the mechanisms of these reactions. About 80% of the students scored greater than 70% on this exam, and we believe they have a strong grasp of bioorganic chemistry fundamentals. The students who did not meet this threshold generally struggled with concepts of reactivity, correctly drawing chemical structures, and drawing reasonable electron flow. Implementing optional review sessions at the beginning of the course, which cover what chemical structures represent and how to draw reaction mechanisms may help these students with background material needed for the course.
c. Recommendations for Improvements/Changes:

- Describe any program changes (e.g., curriculum, instruction, etc.) that will be implemented.

Student comments from the exit interview are included below. They indicated we might want to consider including more opportunities for students to present to their classmates and to read the primary Chemistry literature.

Indirect measure: All graduating seniors in the Class of 2020 were asked to complete an online exit interview in Fall 2020. In the exit interview, two students identifying themselves as graduating with a BS in Chemistry were asked the following questions:

“Please rate how well you feel your education at UNM prepared you to do the following, where 1 = not well at all and 5 = very well. Please explain the rating you assigned above and be as specific as possible about why you assigned the rating you did.”

Present scientific ideas and arguments in a professional setting

Answer 1: 1, I was never given the opportunity to present scientific ideas and arguments in a professional setting at UNM. I did this through my work at SNL.

Answer 2: 4, The labs required reports to be written in the same manner that a scientific article would be written making me very comfortable writing in that format.

Demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry

Answer 1: 1, I was never given the opportunity to demonstrate scientific literacy and be familiar with the status of current research in the field of chemistry at UNM.

Answer 2: 2, Classes did not require the reading of modern papers on topics. The reading of papers was confined to subjects directly related to the topics studied rather than on whatever happens to be current.

No major change of curriculum is recommended.

We recommend increasing course-based research experience in the instruction to foster better lab skills. Faculty should be encouraged to implement professional presentations and assignments that require exposure to scientific literature.
Describe any revisions to your assessment process that will be made for the next reporting cycle.

The following is the table for the SLOs to be assessed and which course data will be collected from.

<table>
<thead>
<tr>
<th>SLO</th>
<th>Year 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> <strong>Content Mastery:</strong> Understand major chemical concepts, theoretical principles and experimental findings in the field of chemistry</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Be able to employ critical thinking to solve problems using multiple layers of data analysis</td>
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<tr>
<td></td>
<td>A2. CHEM 421/425</td>
</tr>
<tr>
<td></td>
<td>Exit interview</td>
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<tr>
<td><strong>B</strong> <strong>Lab Skills:</strong> Demonstrate the ability to construct and test hypotheses using modern laboratory equipment and appropriate quantitative methods</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Construct and test hypotheses</td>
</tr>
<tr>
<td>6</td>
<td>Interpret experimental results and draw conclusions</td>
</tr>
<tr>
<td></td>
<td>B1. CHEM 1225L</td>
</tr>
<tr>
<td></td>
<td>B6. CHEM 411L</td>
</tr>
<tr>
<td></td>
<td>Exit interview</td>
</tr>
<tr>
<td><strong>C</strong> <strong>Communication Skills:</strong> Convincingly present scientific data and arguments in an oral and written format</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Write coherent scientific reports</td>
</tr>
<tr>
<td></td>
<td>C2. CHEM 2230L</td>
</tr>
<tr>
<td></td>
<td>Exit interview</td>
</tr>
<tr>
<td><strong>D</strong> <strong>Professional Development:</strong> Be prepared for entry into graduate school or professional school (e.g. medical, dental, pharmacy, etc) or the chemical industry or government service.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Have general skills to work in small groups to accomplish scientific projects</td>
</tr>
<tr>
<td></td>
<td>D2. CHEM 457/471</td>
</tr>
<tr>
<td></td>
<td>Exit interview</td>
</tr>
</tbody>
</table>

d. How, when, and to whom will results and recommendations be communicated?

- The results and recommendation of this year’s assessment were summarized and distributed to all faculty members through an e-mail and a discussion in the faculty meeting in the spring semester of 2021.
- The recommendations will be discussed in the TA training sessions and by the Chair with individual faculty members who teach the undergraduate courses.
Evidence Indicates New Placement for General Chemistry

The current cutoff score (25, shown as the red line) of ACT math requirement for CHEM 121 does not have any predicted power. In the figure below, the mean ACT math scores from different grade groups do not show any correlation with the grades the students received from the course. For example, students received an F have the mean ACT math score higher than students received a B, a C, or a D. Also, the mean scores from all grade groups including DFW groups are much higher than the required score of 25, indicating the current ACT math requirement does not provide any predicted power and is unjustifiably prohibited students with lower ACT math scores from taking this course. As the result, students’ graduation is delayed.

When we further examined the choice of ACT math score for the pre-req requirement, we found that the distribution of ACT Math scores from students with a passing grade (ABC, red) and that of a failing grade (DFW, blue) are largely overlapped (Figure below). Regardless which score to be selected as the cutoff score, a significant percentage of students will be included from both groups. As a result, a high percentage of students (about 20% or 200 students) with ACT below 25 cannot register into the course even though they have a similar probability of earning a passing grade in the course to those scored 25. Why do we place an arbitrary block to stop these students from taking the General Chemistry course?

Another pre-requisite the students can use to register for CHEM 121 is a passing grade from Math 121. From our data it shows that students need to earn an A from Math 121 in order to have a medium chance of receiving a passing grade from CHEM 121 (4 grade point in the chart below). Earning a B (3 grade point) from math will only give students a 50/50 chance of passing the chemistry. If a student passed the math with a C (2 grade point), the chance to fail the chemistry course is much higher than to pass it. With the majority of students received a B or C from the math course, we have misinformed our students about their readiness to take chemistry by using the college algebra course as a pre-requisite requirement.
The ALEKS placement can have a much better prediction power for student’s performance in chemistry than either ACT math score or math courses can. The following data were collected from the pre-semester ALEKS placement between 2014 and 2016. The ALEKS group consists of students who voluntarily took the 3-week ALEKS pre-semester placement course. The ALEKS group shows a much higher passing rate (ABC) than the non-ALEKS group. The ALEKS group also received more A’s and B’s than the non-ALEKS group. In addition, students who did not take ALEKS had a much higher W rate than those who took pre-semester ALEKS.

ALEKS provides not only an accurate assessment about student’s math skills required for learning general chemistry, but also a comprehensive assessment about the overall chemistry knowledge. The unique feature of adaptive learning using Knowledge Space Theory (KST) from ALEKS allows learners to quickly gain mastery of the required knowledge they are missing. The figure below shows how continue practicing ALEKS improves student’s chance to receive a better grade in CHEM 121. The solid reds are student who practices ALEKS for three weeks and received the greatest number of ABC grades from chemistry. The shaded red in pattern are students completing the initial check but did not practice any ALEKS topics. They both have a better prediction of student’s outcomes in chemistry.
Beside the content knowledge, the final scores of ALEKS also inform about a student’s ability and motivation to deal with stress during learning. The following graphs demonstrate the different behaviors between ABC and DFW students from the ALEKS group. These graphs clearly showed that the passing students have much greater improvement from the initial to the final scores, indicated by the shift of the distribution curve, whereas the failing students barely showed any improvement. This difference makes ALEKS a unique choice for placement.

A predicted Model

The predicted models were established using data from Fall 2000 to Spring 2015, which demonstrated excellent predictions using ALEKS as a predictor.

The predicted model estimated that the ALEKS group drops the probability of receiving a passing grade by 6.5% if these students do not practice ALEKS, and the non-ALEKS students increase their chance to receive a passing grade by 7% if they practiced ALEKS.
Between 1\textsuperscript{st} generation college students and non 1\textsuperscript{st} generation college students

The achievement gap is reduced by 95\% using ALEKS preparation.

![Passing rate gap between 1st generation and non 1st generation students](image)

Between Male and Female students

The achievement gap is reduced by 94\% using ALEKS preparation.

![Passing rate gap between male and female students](image)

Gaps Between different ethnicity groups

<table>
<thead>
<tr>
<th>Ethnicity Group</th>
<th>% reduction of gap</th>
<th>% improved in grade by ALEKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>white-Hispanic</td>
<td>82.46</td>
<td>white</td>
</tr>
<tr>
<td>white-Asian</td>
<td>14.17</td>
<td>Hispanic</td>
</tr>
<tr>
<td>white-native</td>
<td>38.05</td>
<td>Asian</td>
</tr>
<tr>
<td>Hispanic-Asian</td>
<td>32.48</td>
<td>black</td>
</tr>
<tr>
<td>Hispanic-native</td>
<td>29.11</td>
<td>native</td>
</tr>
<tr>
<td>Asian-native</td>
<td>30.56</td>
<td>other</td>
</tr>
</tbody>
</table>

The large gaps between black students and other ethnicity groups is mainly due to very small sample set from these students. All other gaps were much smaller from ALEKS group. More research needs to be done for Black and other ethnicity group.
Dear Alumni, Colleagues, and Friends,

I hope that this newsletter finds you and your loved ones healthy and safe.

We are currently living in extraordinary times. All of our lives have been impacted in some way by this global pandemic. I know some members of our community have been personally affected by this virus. Some have been seriously ill, and unfortunately, some have heartbreakingly lost loved ones. During these difficult times it is easy to feel isolated and alone, therefore, I encourage us all to reach out and call, or text, or even zoom with those that you wish you could see over the holidays. Together, as a community, we will get through this.

Within the department, we have completely changed how we conduct research and educate our students. Our students have adapted to online education, while the faculty and graduate students have been forced to conduct world class research with limited interaction and at a reduced capacity. All this while our building is undergoing a massive $16 million renovation. Our campus is certainly different now than any other time I can remember in my 15 years as a faculty member at UNM.

However, despite all these challenges, the chemistry community at UNM is still finding a way to thrive. I am extremely proud of our students, faculty, and staff, and how we have been able to rapidly transform our research and educational missions. I continue to be amazed by the resilience of our students and the dedication of our faculty, teaching assistants, and staff.

In this newsletter I would like to share a few of the many achievements within the department.

Sincerely,

Jeremy S. Edwards
Professor and Chair
Dr. Susan Atlas joined UNM Chemistry and Chemical Biology in August 2020 as Associate Professor

Dr. Susan Atlas joined UNM Chemistry and Chemical Biology in August 2020 as a tenure-track Associate Professor. Susan is a theoretical chemical physicist working on fundamental and applied problems in electronic structure and molecular dynamics, quantum information science, chemical and synthetic biology, materials physics, and genomics. A common theme in her work is finding ways to identify emergent patterns in the interacting entities of a complex system—whether these be electrons, atoms, molecules, or proteins.

Susan received her B.A. in Mathematics and Physics from Queens College, City University of New York, and her A.M. in physics, and PhD in chemical physics, from Harvard University. Her dissertation proposed one of the earliest van der Waals density functionals, based on a nonlocal electron gas theory of the atom-in-molecule. She was a postdoctoral fellow at the Los Alamos Center for Nonlinear Studies and Chemical and Laser Sciences Division before joining UNM as a research professor in Physics and Astronomy. She also served as Director of the UNM Center for Advanced Research Computing, and as Founding Director of the UNM Cancer Center Bioinformatics and Computational Biology Shared Resource, where she helped pioneer novel machine-learning techniques for genomic analysis.

Dr. Dongchang Chen will join UNM Chemistry and Chemical Biology in January 2021 as Assistant Professor

Dr. Chen will join UNM Chemistry and Chemical Biology January 2021 as a tenure-track Assistant Professor. Dr. Chen’s research seeks to resolve critical chemical processes for energy storage and conversion materials via advanced spectroscopic approaches. The obtained knowledge will serve as guiding principles for systematic materials design and address outstanding challenges in energy and environmental applications.

Dr. Chen worked as a postdoc researcher in the Energy Storage and Distributed Resources Division of Lawrence Berkeley National Laboratory since 2017. His postdoctoral work mainly emphasized on investigating working principles and design strategies for high-energy density Li-ion battery cathode materials. He obtained his Ph.D. degree in chemistry from Georgia Institute of Technology, where he studied reaction mechanisms and surface/interfacial phenomena for various energy storage applications via in situ/operando Raman spectroscopy. He received his B.Sc. Degree in chemical physics from University of Science and Technology of China in 2011.
Dr. Justin Elenewski will join UNM Chemistry and Chemical Biology in August 2021 as Assistant Professor

Dr. Elenewski will join UNM Chemistry and Chemical Biology in August 2021 as a tenure-track Assistant Professor. Justin’s research addresses a range of topics in theoretical chemical physics, with an emphasis on transport dynamics (both quantum and classical) in systems that are perturbed into strongly nonlinear and nonequilibrium regimes. His interests further extend to strong/intense light-matter interactions, materials under extreme conditions, quantum device technologies, and quantum algorithms for electronic structure, energy landscapes, and materials design.

Dr. Elenewski currently serves as an Assistant Research Scientist in the Institute for Research in Electronics and Applied Physics at the University of Maryland and in the Physical Measurement Laboratory of the National Institute of Standards and Technology. His studies at NIST include physical mechanisms for thermal, ionic, and electronic transport in complex materials. Prior to this, Justin was a postdoc at The George Washington University, where his research spanned from quantum transport processes to vibrational energy transfer in molecular materials. Justin received his Ph.D. from Virginia Commonwealth University - studying protein dynamics alongside ab initio methods for computational enzymology and his B.S. from The University of Illinois Urbana-Champaign.

PhD and MS Graduate Programs in Chemistry and Chemical Biology

Research Opportunities

Chemical Biology

Computational Chemistry

Materials & Energy

Why Choose UNM?

• New Mexico’s Flagship University
• State-of-the-Art Facilities
• Research Funded by the NSF, NIH, DOE, DOD, and more
• Competitive Financial Support
• 310 Days of Sunshine & ~60° Average Temp
• Tackle Global Challenges with:
  • Los Alamos National Laboratory
  • Sandia National Laboratories
  • Air Force Research Laboratory
• Natural beauty - Situated Between the Sandia Mountains and the Rio Grande

Application Deadline
1/15/2021

Visit chemistry.unm.edu for more information.
UNM Chemistry and Chemical Biology has had a strong research year

Dr. Sherman Garver received a large anonymous donation to support his important work on the Niemann-Pick C1 (NPC1) gene/protein.

Dr. Garver has been a leader in this field for over 25 years and his contributions have shown that NPC1 is not only responsible for the rare inherited disease, it is now also associated with a multitude of human metabolic, neurological and infectious diseases.

Dr. Garver has been involved in physically mapping and cloning of the mouse NPC1 gene, which was used to identify the human NPC1 gene. He also was able to determine the cellular location and biological function of the encoded NPC1 protein. While his main goal continues to be to identify therapies for NPC1 disease, two of which (beta-cyclodextrin and N-butyl-deoxynojirimycin or Miglustat) are now being used to treat NPC1 patients.

Prof. Brian Gold was awarded a grant as part of the Metals in Biology NIH funded Center of Biomedical Research Excellence.

This center is dedicated to providing infrastructure and additional resources to UNM faculty for studying the impact metals and metal contaminants on human health.

The National Science Foundation has renewed a grant to Prof. Hua Guo for three years.

This grant will allow the Guo group to further their theoretical investigations of gas-surface interactions and the corresponding reaction dynamics. The issues include the impact of energy dissipation on the scattering, adsorption, and chemical reactions. Such knowledge is vital to our fundamental understanding of surface chemistry and to help designing new and more effective catalysts.

Prof. Jeremy Edwards has been awarded a three year grant from Sandia National Laboratories.

This grant will allow Prof. Edwards to collaborate with the Sandia scientists and use genomics tools and technologies to understand viruses and viral evolution.
Prof. John Grey published the “Feature Article” which was featured on the cover of the May edition of the Journal of Physical Chemistry. The article was entitled “Triplet Population Dynamics of Single Conjugated Polymer Molecules and Nanoscale Assemblies.” Prof. Grey and his group used stochastic photodynamic models that are used to extract key kinetic constants, including bimolecular triplet–triplet annihilation, that tend to exhibit pronounced dependences on polymer conformational ordering. Prof. Grey postulates that molecular-level control can be harnessed to more accurately manage triplet yields and interactions over a large range of time scales, which has potential uses in multiexciton harvesting schemes, such as singlet fission, which has important ramifications for conjugated organic materials used in optoelectronic devices.

Prof. Terefe Habteyes published a prestigious invited Perspective article in the Journal of Physical Chemistry. Hot electron transfer to unoccupied molecular orbitals is the most popularized mechanism for plasmon enhanced photocatalytic reactions, while a few reactions have been attributed to near-field enhanced intramolecular adsorbate electronic photoexcitation. In this Perspective, Prof. Habteyes argues that the role of hot electrons may be limited to preparing anionic complexes that can undergo further chemical transformation via photoexcitation to dissociative potential energy surfaces.

Prof. Hua Guo published an article in collaboration with an experimental group at the University of Gottingen on the prestigious journal Science on the kinetics of molecular adsorption on surfaces. This is the first time when the microscopic pathways towards thermal adsorption of a gaseous molecule (CO) on a metal surface (Au) are mapped out by combining experimental temperature dependence of the scattering data and density functional theory. This work was funded by a grant from the National Science Foundation.

Prof. Jeremy Edwards, along with collaborators at Harvard Medical School and UNIST (in South Korea) sequenced the full genome of a whale shark, and they published this in the Proceedings of the National Academy of Sciences. Prof. Edwards and his collaborators compared the whale shark genome to that of other animals and uncovered a number of genomic features that correlate with lifespan and other animal traits. The group found that gene length, particularly neural gene size, was linked to longer lifespans.

Prof. Martin Kirk published a cover article in Chemical Science entitled “Transferrable Property Relationships Between Magnetic Exchange Coupling and Molecular Conductance.” In this article, Prof Kirk and coworkers computed conductance through $\text{Au}_n$-$\text{S}$-$\text{Bridge}$-$\text{S}$-$\text{Au}_n$ (Bridge = conjugated organic σ/π-system) constructs and compared the results to experimentally-determined magnetic exchange coupling parameters in a series of heterospin biracial Radical-Bridge-Radical complexes. The group found that there is a nonlinear functional relationship between the biradical magnetic exchange coupling and the computed conductance. The results of these observations were described in valence bond terms, with resonance structure contributions to the ground state bridge wavefunction being different for Semiquinone-bridge-NitronylNitroxide and $\text{Au}_n$-$\text{S}$-$\text{Bridge}$-$\text{S}$-$\text{Au}_n$ systems.
Prof. Brian Gold published his first peer reviewed manuscript at UNM in ACS Catalysis, “Unique, yet Typical Oxyanion Holes in Aspartic Proteases.” This manuscript describes a previously unrecognized mode of catalysis and provides a new strategy for rational drug design.

Professor Yi He is leading the study funded by UNM’s Substance Use Disorders Grand Challenge Award. Dr. He is leading a research project funded by UNM’s Substance Use Disorders Grand Challenge Award that investigates a potentially groundbreaking way to treat drug addiction using computational modeling to understand the role of the PICK1 protein in the brain of an individual suffering from drug addiction. To read the full article, go to http://news.unm.edu/news/unm-professor-uses-computational-simulations-to-advance-substance-use-disorder-treatment

Dr. David Whitten honored as 2020 STC UNM Innovation Fellow. UNM Rainforest Innovations announced its Dr. Whitten as the 2020 Innovation Fellow. This award goes to a single investigator at UNM whose individual work is not only driven by the pursuit of innovation and knowledge, but also by the objective of positively impacting our society. David Whitten has more than 50 years of experience as a scientist and an academic. He joined The University of New Mexico in 2005 and has since excelled as an inventor, disclosing 33 technologies and receiving 17 issued patents. To read entire article: https://news.unm.edu/news/david-whitten-honored-as-2020-stc-unm-innovation-fellow

Please join us for our virtual seminar series in the Spring 2021 semester each Monday at 12:00pm Mountain Time. The schedule is available on our website: https://chemistry.unm.edu/ https://unm.zoom.us/j/93747381964
Gold Lab works toward improved HIV treatment

Chemistry Assistant Professor Brian Gold is using computational modeling to learn about HIV. Dr. Gold hopes that a better understanding of the chemical processes that allow the virus to flourish will enable him and his lab to design improved treatments. Specifically, the Gold Lab is looking into the mechanisms of aspartic protease—a type of enzyme that breaks down proteins and peptides. The HIV virus cannot survive and reproduce without the work of its specific aspartic protease, so stopping the action of this enzyme can keep the virus from proliferating. Dr. Gold published his first paper at UNM on this topic (ACS Catalysis) in the Fall 2020 semester.

Prof. Hua Guo was awarded with a Humboldt Research Award by Germany’s prestigious Alexander von Humboldt Foundation. “Every year, the Alexander von Humboldt Foundation grants up to 100 Humboldt Research Awards to internationally leading researchers of all disciplines from abroad in recognition of their academic record to date.”

Visit the UNM Foundation website to donate to our department. 
https://www.unmfund.org/fund/chemistry-chairmans-excellence-fund/
Amy Overstreet and Laura Ingersol for winning the Smith/Dow award for 2020

Amy Overstreet (Prof. He group) has made overwhelming progress in the CCB program. She has completed two first author manuscripts, one has been accepted and the other is currently under review. Amy has been developing computational chemistry tools to study PDZ protein domains. PDZ domains are highly abundant protein-protein interaction domains found in signaling proteins and play a critical role in many biological processes such as managing cell polarity, regulating tissue growth and development, trafficking of membrane protein receptors and ion-channels, and regulating cellular pathways. Despite the importance of the PDZ protein family, few computational efforts have been put towards the understanding the molecular functions PDZ domain. Amy’s work focuses on the changes in structure and dynamics of PDZ domain upon ligand binding, and she has provided a thorough analysis of both dynamic changes and electrostatic allosterism of the PDZ domain. This work is significant and contributes a more complete understanding of allosterism across this important protein family and could lead to new therapeutics to combat drug and substance addiction.

Laura Ingersol (Prof. Kirk group) has been working on two extremely difficult bioinorganic projects, and she has made considerable progress on both. Her projects have focused on pyranopterin containing molybdenum (Mo) enzymes, which are widely found in bacteria, archaea, and eukarya. Humans possess four of these enzymes, which function to hydroxylate a wide variety of purine-based drugs and heterocyclic metabolites, oxidize aldehydes, detoxify sulfate by oxidizing it to sulfate, and synthesize the biological messenger molecule nitric oxide via the one-electron reduction of nitrite. The importance of Moco in humans is exemplified by the fact that mutations in the Moco biosynthetic pathway lead to Moco deficiency, a severe neonatal metabolic disorder that results in neurodegeneration and infant death due to a loss in sulfite oxidase (SO) activity. Laura is the first author on two manuscripts that have provided new insights into the chemical functions of the molybdenum enzymes.
The Chemistry and Chemical Biology Department second phase renovations are proceeding well. As of today, the abatement and demolition have been completed and no huge challenges were discovered. We are currently beginning the construction of the office and research space. Once complete, the project will modernize all of our research facilities and create new state-of-the-art laboratories for further departmental growth. We anticipate the building renovations will be completed by August 2021.
<table>
<thead>
<tr>
<th>Full First and Last Name</th>
<th>Faculty Appointment</th>
<th>Institution(s) Attended, Degrees Earned, and/or active Certificate(s)/Licensure(s)(e.g., University of New Mexico—BS in Biology; University of Joe Dane—MS in Anthropology; John Doe University—PhD in Psychology; CPA License—2016-2018)</th>
<th>Program Level(s) (Please leave blank or provide “N/A” for each level(s) the faculty does not teach at least one course.)</th>
<th>Faculty Credentials</th>
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</thead>
</table>
| Atlas, Susan R.         | TAP                 | *Harvard University, Ph.D. Chemical Physics, November 1988   
*Harvard University, A.M. Physics, March 1981  
*City University of New York, Queens College, B.A. summa cum laude, Mathematics/Physics, 1979 | Undergraduate, graduate, Ph.D.  
TDDR                      | TDDR                |
| Cabaniss, Stephen E.   | TP                  | *Ph.D. Environmental Science and Engineering, 1986, University of North Carolina  
*M.S. Environmental Science and Engineering, 1982, University of North Carolina | Undergraduate and graduate  
TDDR                      | TDDR                |
| Chen, Changdong         | TTAP                | *Ph. D. in Chemistry, Georgia Institute of Technology2017  
*B. S. in Chemical Physics, University of Sci & Tech of China (USTC) 2011 | Undergraduate, graduate, Ph.D.  
TDDR                      | TDDR                |
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<tr>
<th>Name</th>
<th>Type</th>
<th>Education</th>
<th>Degree Level</th>
<th>TDD</th>
</tr>
</thead>
</table>
| Depperman, Ezra C.    | LT   | *The University of New Mexico PhD, Physical Inorganic Chemistry and Spectroscopy  
ACS, Phi Beta Kappa 1999-2006  
*The University of New Mexico  
BS, Biochemistry  
Cum Laude, Phi Beta Kappa 1993-1998 | Undergraduate | TDD |
Advisor, Dr. George Church  
1999 Ph.D. in Bioengineering, University of California, San Diego  
Thesis Title: Functional Genomics and the Computational Analysis of Bacterial Metabolism; Advisor, Dr. Bernhard Palsson.  
1997 M.S. in Bioengineering, University of California, San Diego  
1995 B.S. in Mechanical Engineering, University of Texas, Arlington, Summa Cum Laude | Undergraduate, graduate, Ph.D. | TDDR |
| Evans, Deborah G.     | TP   |  *PhD 1987 University of North Carolina, Analytical Chemistry  
*MS 1983 Cornell University, Analytical Chemistry  
*BS 1981 University of North Carolina, Chemistry | Undergraduate, graduate, Ph.D. | TDDR |
| Fulghum, Julia E.     | TP   |  *Arnold O. Beckman Postdoctoral Fellow, Massachusetts Institute of Technology 2015 –2019 Advisor: Ronald T. Raines  
Massachusetts Institute of Technology, 2017 –2019  
*University of Wisconsin–Madison, 2015 –2017 Graduate Research/Teaching Assistant,  
*Florida State University2009–2014Advisor: Igor V. Alabugin | Undergraduate, graduate, Ph.D. | TDDR |
| Grey, John K.         | TP   |  *Ph.D., Chemistry (2004) McGill University, Montreal, Quebec  
*B.S., Chemistry (1999) Michigan Technological University, Houghton, MI | Undergraduate, graduate, Ph.D. | TDDR |
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<th>Name</th>
<th>Center</th>
<th>Type</th>
<th>Education and Experience</th>
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<tbody>
<tr>
<td>Guo, Hua</td>
<td>TDP</td>
<td></td>
<td>1988—1990 Postdoctoral Fellow (with Prof. G. C. Schatz)Northwestern University, Evanston, IL 60208, USA 1985—1988 D. Phil. in Theoretical Chemistry (with Prof. J. N. Murrell, FRS). 1982—1985 M.Sc. in Theoretical Chemistry, Department of Chemistry, Sichuan University, Chengdu, China. 1978—1982 B.Sc. in Chemistry Department of Basic Sciences, Chengdu Institute of Electronic Engineering, Chengdu, China</td>
<td></td>
<td>Undergraduate, graduate, Ph.D.</td>
<td></td>
</tr>
<tr>
<td>Habel-Rodriguez, Diana</td>
<td>LT</td>
<td></td>
<td>2013 PhD in Chemistry with PhD minor in Nanoscience &amp; Microsystems, University of New Mexico 2003 Bachelor of Science in Biology, University of New Mexico 2003 Bachelor of Science in Chemistry, University of New Mexico</td>
<td></td>
<td>Undergraduate</td>
<td>TDO</td>
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<tr>
<td>He, Yi</td>
<td>TTAP</td>
<td></td>
<td>*Ph.D. 2009 -Biophysics, Huazhong University of Science and Technology, Wuhan, China  *B.E. 2003 Computer Science, Huazhong University of Science and Technology, Wuhan, China  *B.S. 2003 Applied Physics, Huazhong</td>
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<td>Name</td>
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<td>Field/Title</td>
<td>Advisor/Grade</td>
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<tr>
<td>Ho, Kuang-Chiu</td>
<td>LT</td>
<td>*Ph.D. (1993) Department of Chemistry, University of New Mexico, Albuquerque, NM, major in (Biophysical) chemistry, Dissertation title: &quot;The theory and application of inverse light scattering problems by using Mueller Matrix measurements&quot;, Dissertation advisor: Dr. Fritz Allen</td>
<td>*MS (1989) Department of Chemistry and Geology, Minnesota State University, Mankato, MN</td>
<td>Undergraduate</td>
<td>TDDR</td>
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<tr>
<td>Keller, David J.</td>
<td>TAP</td>
<td>*1979-84 Ph.D. Chemistry, University of California, Berkeley *1975-79 B.S. Chemistry, Pacific Lutheran University</td>
<td>*1975-79 B.S. Chemistry, Pacific Lutheran University</td>
<td>Undergraduate, graduate, Ph.D.</td>
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<tr>
<td>Kirk, Martin L.</td>
<td>TDP</td>
<td>*Postdoctoral, 7/90-9/93, National Science Foundation Postdoctoral Fellow, Stanford University, Stanford, CA 94305. (Prof. Edward. I. Solomon) *PhD, 8/90, The University of North Carolina at Chapel Hill, Chapel Hill, NC, Inorganic Chemistry, Dissertation Title: &quot;Unusual Linear Chain Magnetism&quot; Prof. William E. Hatfield, advisor. *Bachelor of Science, 6/85, West Virginia University, Morgantown, WV, Chemistry. Cum Laude</td>
<td>Undergraduate, graduate, Ph.D.</td>
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<tr>
<td>Name</td>
<td>Degree</td>
<td>Institution</td>
<td>Field</td>
<td>Advisor(s)</td>
<td>Undergraduate or Graduate</td>
<td>Additional Notes</td>
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<tr>
<td>Martucci, Mary B.</td>
<td>LT</td>
<td>Ph. D. Chemistry - May 2012 COLORADO STATE UNIVERSITY Fort Collins, CO</td>
<td>Chemistry, cum laude; French minor - May 2005 ALLEGHENY COLLEGE Meadville, PA</td>
<td>Undergraduate</td>
<td>TDD</td>
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<tr>
<td>Ray, Alisha</td>
<td>LT</td>
<td>*M.S., July 2005, University of New Mexico, Chemistry &quot;An Analysis of Phosphate’s Effect on Iron Incorporation and Release from Ferritin” (passed with distinction), advisor: Richard Watt *B.A., May 2001, University of New Mexico, Chemistry &quot;B.S., May 2001, University of New Mexico, Anthropology &quot;It’s Not All in Your Head: Determining Biological Affinity Based on Post-Cranial Discriminate Function Analysis”, advisor: Osbjorn Pearson</td>
<td>Undergraduate</td>
<td>Masters only</td>
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<tr>
<td>Whalen, Lisa J.</td>
<td>LT</td>
<td>*University of Colorado, Boulder, CO, Ph.D. Chemistry, August 2004, Advisor: Professor Randall L. Halcomb</td>
<td>Undergraduate</td>
<td>TDD</td>
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**Appendix L: Peer Comparison**
(FOR USE IN CRITERION 7)

With the understanding that not all programs are included in every peer institution, the APR Office recommends selecting 3 peer institutions to use as comparisons.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Total University Enrollment</th>
<th>Unit Undergraduate Degrees/Certificates Offered</th>
<th>Unit Undergraduate Student Enrollment</th>
<th>Unit Graduate Degrees/Certificates Offered</th>
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<th>Total # of Unit Faculty</th>
<th>Status/Ranks/Comparisons (i.e., program goals, curriculum, faculty, and students, etc.)</th>
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<td>15 TT 5.5 Lecturers</td>
<td>University Ranking: #187 (US) Chemistry graduate program ranking: #106 (US)</td>
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<td>Texas Tech University</td>
<td>38,742</td>
<td>BA/BS Chemistry, BA/BS Biochemistry</td>
<td>236-BA/BS Chemistry, 414-BA/BS Biochemistry</td>
<td>Masters/PhD</td>
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<td>34</td>
<td>University Ranking: #217 (US) Graduate School Ranking: #122 (US)</td>
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<td>University of Iowa</td>
<td>30,448</td>
<td>BS, BA</td>
<td>72-BS, 105-BA</td>
<td>PhD</td>
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<td>32</td>
<td>University Ranking: #88 Graduate School Ranking: #67 (US)</td>
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<td>Colorado State Univ.</td>
<td>27,835</td>
<td>BS</td>
<td>161-BS</td>
<td>MS, PhD</td>
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<td>39</td>
<td>University Ranking: #153 Graduate School Ranking: #52 (US)</td>
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<td>Date</td>
<td>Equipment Description</td>
<td>Manufacturer</td>
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<td>1/21/20</td>
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<td>11/4/96</td>
<td>HEATER LAB</td>
<td>PerkinElme</td>
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Shared Departmental Equipment

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<td>Labconco</td>
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<tr>
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<td>Centrifuge/AllegraX-30R</td>
<td>BeckmanCoulter</td>
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<td>Waterscorp</td>
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<td>Advance III 399 High Performance Digital</td>
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Appendix N

Chemistry Faculty’s Participation in student success and support initiatives

Student Experience Project

The Student Experience Project is a collaboration of 6 US universities and several learning partners to put into practice more than a decade of social psychology research demonstrating that positive experiences of community, belonging, and support on campus and in the classroom can increase a student’s likelihood of persevering through academic challenges toward graduation. These interventions focus on growth mindset and social belonging, which have been shown to reduce equity gaps in student experience and achievement. CCB Senior Lecturer III Sushilla Knottenbelt serves as STEM lead for the UNM Student Experience Project. Members of the General Chemistry instructors group Diana Habel-Rodriguez and Ezra Depperman are SEP Implementation Fellows, committing to an extensive set of implementations and measurement of student experience over the semester, as well as being a part of a community of practice at UNM. Tracy Terry is an Exploratory Fellow.

Peer Learning Facilitators

Peer Learning Facilitators (PLFs) are undergraduates who have been successful in a particular course who return to the class to help instructors facilitate active learning during class time. Courses that use active learning show significant gains in student learning and retention (1), especially for students traditionally under-represented in STEM (2). As a result, all students do better, and the achievement gap is reduced. A PLF program benefits three groups, students, instructors and the PLFs themselves. Students benefit from more inclusive course designs that incorporate chances to practice, ask questions and get feedback in class, have more accessible, less stigmatized academic support in difficult classes, and have near peer role models and mentors (ideally who have the demographic of the student body they serve) who reflect that it is possible to be successful in the class and can share their experiences to provide support. Instructors who have support from PLFs in the implementing active learning pedagogies are more to use these high impact practices as a larger instructional team in the room keeps students on task with more access to support. Finally, the PLFs themselves are able to reinforce their own discipline specific content knowledge in preparation for graduate school or pre-professional examinations, develop leadership and other transferable skills, develop mentoring relationships with students as well as significant connections with faculty members. It is expected that this role will provide experience, confidence and connections that will strengthen the chances of acceptance into and success in graduate school. The final important benefit to the PLFs is the opportunity for on-campus employment in a job that will be supportive of the other demands of their time due to their own course load and provide the significant benefits described above.

Chemistry faculty were one of the largest user groups of the Department of Education funded PLF program at UNM. When grant funding ended, the chemistry faculty worked to keep the
program alive when no funding was available by developing a PLF training course in which PLFs could have their service rewarded by course credit. The course was developed by Philip Watje under the supervision of K. Joseph Ho. PLF use continued in the Chemistry Department when it did not exist anywhere else in the University. Chemistry faculty have advocated for the continuing of the program and in Fall 2020, a small institutional pilot PLF program was launched. Since then, Student Fee Review Board funding has been recommended to expand the program, and there has been interest from several other funding sources. Sushilla Knottenbelt is a member of the committee working to institutionalize the Program, and CCB faculty Habel-Rodriguez, Depperman and Terry participated in the pilot semester and continuing.

Table 1. Recent enrollment in Chem1215 and Chem1225 courses and PLF support for selected sections

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course*</th>
<th>Students enrolled</th>
<th>PLF+TA+CAPS</th>
<th>PLFs</th>
<th>Former students</th>
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<td>Chem1225</td>
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<td>3</td>
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<td>5</td>
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<td>Fall 2017</td>
<td>Chem1225 (2x)</td>
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*multiple sections indicated in ( )

Testimonies from Participating faculty members

_Ezra Depperman_

Many of our general chemistry instructors have chosen to participate in the Student Experience Project, a multi-institutional program. SEP uses Copilot-Ascend to periodically administer anonymous surveys to gauge the way members of different groups experience the class in terms of their social belonging, social connectedness, self-efficacy, and growth mindset. SEP fellows meet regularly to share strategies and best practices for improving these outcomes among all groups, including structurally disadvantaged, women, and financially stressed students. Regular surveys not only increase instructor awareness of students’ perceptions, they also give the opportunity to measure the effectiveness of different strategies. The community
of instructors centered around SEP is a resource as both a sounding-board for the nature of the feedback received but also provides a set of simple practices that can be easily implemented to increase the effectiveness of our pedagogy across our diverse student body.

Because of the large enrollments in general chemistry, general chemistry instructors have been early adopters (and strong advocates of) the Peer Learning Facilitator (PLF) program. In this program, students who previously had success in these courses are recruited by the instructor to become PLFs, expanding the teaching team beyond instructor and TA. The role of a PLF may include holding drop-in hours (office hours re-branded via insight gleaned through the Student Experience Project), grading low-stakes assignments, moderating discussion boards, regularly sending out messages of belonging and growth mindset, helping student-groups in breakout rooms in synchronous classes, or other tasks, depending on the course format, as long as it does not involve generating instructional material or grading high-stakes assignments. These PLFs earn upper-division credit, pay, and the opportunity to dabble in being an educator. Students see PLFs as role models who are easy to learn from, being closer to their own stage in life. In carrying a portion of the tasks, PLFs free up a portion of instructors’ time to improve pedagogy and design new activities. PLFs also can provide invaluable feedback to instructors.

Some of our general chemistry instructors and our organic chemistry instructors have begun converting lectures into short (5-10 minute) instructional videos which students can watch outside of a synchronous class. This results in a “flipped classroom” for synchronous classes, where class meeting time can then be used to address student questions, delve deeper into the material, hold discussions, or work on small-group activities. Despite the huge amount of effort and time needed to produce these videos, once they’re made, class time is more flexible and rewarding. For asynchronous classes, we’ve found that students are better able to process information in brief chunks, so the 5-10 minute length is equally effective.

Multiple chemistry lecturers are remote teaching fellows, who are working to support our colleagues in leveraging educational to take full advantage of remote and hybrid pedagogies. Regardless of the particular learning management system employed, the strategic goal is to improve student outcomes. Thus we can encourage our colleagues who are waiting for the rumored implementation of a new LMS to begin with the current system, to take a “plus one” approach. In this way, instructors can add new activities at a reasonable pace, and these resources can be easily migrated to the new platform. A side-effect is that the learning curve for the new LMS will not feel so abrupt for those who’ve dabbled in the current system.

The chemistry department lecturers meet regularly to share ideas and resources and to support each other, fostering belonging and community. We anticipate continuing to do so with the wonderful colleagues who each contribute in their own valuable ways. We anticipate that the university’s adoption of a new learning management system, while it will involve a learning-curve and challenges, will bring the opportunity to more-effectively leverage online and hybrid
teaching strategies. We look forward to working together to migrate our material to the new platform, and to help our colleagues do so as well.

Diana Habel-Rodriquez

Working with PLFs is very rewarding - they are truly dedicated to helping General Chemistry students. The majority of my peer-learning facilitators have actually been students in my own past General Chemistry sections, who then come back to facilitate my general chemistry classes. It is wonderful to see those former students grow in their degree programs, and often I stay in touch for several years and provide letters of recommendation.

Most of my sections have been taught in the learning studio classroom - a collaborative learning space with large, student-centered tables that encourages group work. Some of the in-class exercises we use in General Chemistry I utilize free PhET online simulations from University of Colorado Boulder, for which we wrote activities. In our most recent text book review, we considered the peer-reviewed and openly-licensed (free) OpenStax General Chemistry text as one of our top choices (though we ultimately voted for a different text). The most important resource to me is the community of practice that exists among the teaching faculty in our department. We share materials, best strategies, student review events and much more in our mutual support of one another (NMHEAR presentations in February 2014, 2015).

Recently we have revised the some of our General Chemistry courses to increase our messaging of a growth mindset as well as foster a sense of belonging and community in our students as part of the national student experience project (SEP). This revision has included a restructuring of our syllabus and course site language, changes in the administrative rules of the course as well as additional academic content. One such intervention is a 'test correction exam wrapper.' We have presented this work in the national SEP winter 2021 convening and created a record/guide for the exam wrapper activity for the SEP library (see presentation PowerPoint below)

Reference