

REVIEW OF THE M.S. IN CHEMISTRY

Classification of Instructional Program (CIP) Code: 40.0501
Chemistry, General

OVERVIEW

The M.S. in Chemistry program at Illinois State University is housed in the Department of Chemistry within the College of Arts and Sciences. The department also offers a minor in chemistry, a B.S. in Chemistry, a B.S. in Biochemistry, and two master's level chemistry education programs, the Master of Chemistry Education (M.C.E.) and the Master of Science in Chemistry Education (M.S.C.E.).

Most graduate-level chemistry programs in the United States are designed for students whose ultimate educational goal is a doctoral degree. The graduate chemistry program at Illinois State University is one of several designed exclusively to serve students who seek the master's degree as their terminal degree. An advantage to students who enroll in the master's chemistry program at Illinois State is the opportunity to work closely with tenured and tenure track faculty members on chemistry research and to receive teaching or research assistantships.

Students who complete the master's program at Illinois State qualify for most applied research positions, industrial work, and some community college teaching. Approximately half of program alumni are employed in industry, with pharmaceutical companies such as Abbott Laboratories, AbbVie, Baxter International, Eli Lilly and Company, and Pfizer among the most common industry employers. About one in five program alumni is an educator on the secondary or post-secondary level.

Enrollment, Fall Census Day, 2009-2016 M.S. in Chemistry, Illinois State University

2009	2010	2011	2012	2013	2014	2015	2016
34	35	36	34	32	26	23	26

Degrees Conferred, Graduating Fiscal Year, 2010-2016 M.S. in Chemistry, Illinois State University

2010	2011	2012	2013	2014	2015	2016
13	7	9	13	7	11	14

EXECUTIVE SUMMARY PROGRAM REVIEW SELF-STUDY REPORT

Self-study process. Numerous faculty and staff members of the Department of Chemistry, either individually or as members of department committees, were involved in the multiple-year program review self-study process. The Graduate Programs Committee and the Department Council reviewed the program curriculum and the student learning outcomes assessment plan for the program in light of feedback from the American Chemical Society, which accredits the undergraduate chemistry program, and from the Assessment Advisory Council, a campus-wide committee that support units with their assessment efforts. The Facilities Committee and the liaison between the department and the library were consulted for input on appropriate sections of the self-study report. Students provided input for the study through interviews conducted by the department chairperson at the time of their graduation. Alumni provided input by completing a survey administered by University Assessment Services. The department chairperson wrote the self-study report, drawing on information gathered throughout the review process and on input and feedback provided by both the current and immediate past associate chairpersons.

Program curriculum. The curriculum of the M.S. in Chemistry program is designed to provide students a broad understanding of multiple sub-disciplines of chemistry while simultaneously developing expertise in a specific sub-discipline through original laboratory research. Students hone their laboratory and research skills under the guidance of a faculty mentor. The program requires 31 credit hours, including 21 credit hours of coursework at the 300- or 400-level, a master's thesis, and an oral thesis defense. Courses must be taken in at least four of the following sub-disciplines: analytical chemistry, inorganic chemistry, organic chemistry, physical chemistry, biochemistry, and chemistry education. Students develop oral and written communication skills through teaching and through two seminar presentations, in addition to the thesis and oral defense. Many theses are eventually published in part or in whole in the scientific literature.

Program or academic unit faculty. The Department of Chemistry consists of 20 full-time tenure track faculty members (as of fall 2016). Three are currently in administrative roles: the department chairperson, the Associate Vice President for Research and Graduate Studies, and the director of the Center for Mathematics, Science, and Technology. All tenure track faculty members are full members of the graduate faculty at the University or have applied for that designation. All tenure track faculty members (including the three administrators) teach and mentor students in the program. In a typical academic year, every tenure track faculty member supervises and advises a student in the program, participates on a thesis committee, or teaches a graduate level course. Faculty members consider each of these roles critical to their work in the department.

Program goals and quality indices. Faculty has adopted four student learning outcomes for the M.S. in Chemistry program: 1) students will have a strong understanding of the fundamental basis of the science of chemistry through mastering key concepts in at least four of the specific areas of physical chemistry, organic chemistry, inorganic chemistry, analytical chemistry, and biochemistry and with advanced work in one of the areas through independent investigation (research); one of the areas may be chemical education; 2) students will develop information and communication skills (oral, written, and computer) needed to be a professional chemist, to be successful in doctoral study in the discipline, or to enter a program leading to a degree in medicine or a related field; 3) students will develop problem-formulating and problem-solving skills relevant to the field of chemistry; and 4) students will develop safe and effective laboratory techniques, including those for chemical handling and use of chemical instrumentation.

Student learning outcomes assessment plan and process. Assessment data are collected each semester from course instructors, the stockroom manager (related to safety training), and thesis committee chairpersons. Data are compiled by the department chairperson and are discussed with the Department Council. Following those discussions, assessment results are shared with the Graduate Programs Committee. The report of assessment results is also made available to all faculty members. Any party to the assessment process may initiate revision of the assessment plan. The plan revision process begins with consideration by the Graduate Programs Committee. No changes to the assessment plan have been made since its completion as the time of 2008-2009 program review. There is a desire in the department to more closely align assessment strategies for the M.S. in Chemistry program with current department goals and with assessment standards of the American Chemical Society, which accredits the undergraduate chemistry program.

Specialized accreditation. While the American Chemical Society (ACS) accredits undergraduate chemistry programs, neither ACS nor any other professional association accredits or otherwise recognizes graduate-level chemistry programs. The B.S. in Chemistry program was accredited by ACS in 2013 for a six-year period.

Responses to recommendations resulting from the previous program review. The 2008-2009 review of the M.S. in Chemistry program by the Academic Planning Committee resulted in five recommendations. First, the Academic Planning Committee asked the department to continue its efforts to attract highly qualified and demographically diverse applicants to the program. While department efforts since then have attracted highly-qualified applicants, achieving racial and ethnic diversity across the student population remains a challenge for the program as it does for postsecondary chemistry and physical sciences programs nationally. Second, the Academic Planning Committee asked the department to work with Milner Library to enhance research resources for the M.S. in Chemistry program. The library liaison in the Department of Chemistry has worked closely with the Milner Library liaison to the department to maintain access to research literature needed to support the graduate program curriculum and faculty research. However, budget realities university-wide have necessitated prioritization of research resources acquired by the library in most disciplines including chemistry. In some disciplines, including chemistry, cancellation of

some journal subscriptions has been necessary. Working with the department, Milner Library has developed a strategy of retaining access to key chemistry journals and paying for increases in their subscription costs by terminating subscriptions to several journals peripheral to the curriculum or having limited demand among chemistry faculty and students. The library has adopted a pay-for-use model to provide access to content of journals whose subscriptions the library has cancelled. Third, the Academic Planning Committee has asked the department to continue exploring options for updating its equipment and facilities. The department has been successful in this effort thus far. The department has been able to purchase several large- or medium-sized instruments through federal grants and strategic budget carryover, including an x-ray diffractometer, a liquid chromatography-mass spectrometry system, a Raman spectrometer, a fluorimeter, simultaneous thermogravimetry and differential scanning calorimetry instrumentation, vacuum pumps, and gas chromatography-mass spectrometry instrumentation. A change in university policy to allow small equipment used in classes to be purchased using student-paid materials fees rather than department equipment funds has allowed the department to target its limited equipment funds for purchase of larger, more costly equipment. Since adoption of that policy change, the department has purchased at least one medium-sized instrument from the department equipment fund each year in addition to purchasing major equipment with federal grant funds.

Changes in the academic discipline, field, societal need, and program demand. Since the 2008-2009 program review, demand for chemists has declined nationally, especially for newly-graduated chemists, and unemployment among chemists is now higher than it has been in many years. The number of entry level positions available to new chemistry program graduates has declined as more experienced candidates fill those positions. This situation is unlikely to change with the continued consolidation of large multinational corporations. Chemistry program graduates now rarely work for a single company for their entire career; rather they typically begin in a temporary or work-for-hire arrangement, move into more permanent positions, and often move from one company to another. Employers now expect graduates to have computer literacy, safety, ethics, oral and written communication, and information literacy skills in addition to traditional laboratory skills. Many prospective students still perceive obtaining a master's degree as a means of advancing their career prospects and overcoming some job market entry barriers that chemists with only a bachelor's degree face. The thesis-based M.S. in Chemistry program at Illinois State continues to meet the needs of students who seek a rigorous graduate chemistry program but do not desire (or need) a doctorate in the discipline.

Major findings of this program review self-study. Based on this extensive program review, faculty of the M.S. in Chemistry program finds the program to be in good standing. Graduates report high levels of satisfaction with the program, particularly the level of personal interaction with faculty members and the degree to which the program prepared the students for their careers. Students in the program continue to win college and university awards for research and teaching, including the James L. Fisher Outstanding Thesis award several times since the last program review and at least three Outstanding University Graduate Teacher awards during that period. One concern articulated during this program review that particularly merits attention by the faculty in coming years relates to course scheduling. Attempts to offer advanced courses in many sub-disciplines has strained faculty and has frustrated students awaiting availability of courses in their chosen sub-discipline. Alternative ways of rotating courses to better serve students in the program will be investigated by faculty.

Initiatives and plans for the next program review cycle. *Advancing Graduate Education in the Chemical Sciences*, a 2012 report of an American Chemical Society (ACS) presidential commission, called on chemistry departments to revisit their programs given that most are based on a system of graduate instruction in vogue in the 1950s. The graduate program in chemistry at Illinois State took its current form in the 1960s but is based on that same 1950s system. The ACS report stresses the need for greater emphasis in contemporary chemistry programs on communication skills and safety, including at the graduate level. Addressing these skills in the M.S. in Chemistry program is a topic for discussion among faculty members during the next program review period. Other issues identified through this program review process include diversity among graduate students and department faculty, graduate assistantship funding, and whether to morph the master's program into a doctoral program. All merit investigation by program faculty in coming years. A prudent first action by the department toward addressing these and other issues is developing a new strategic plan to replace the plan adopted by the department more than 12 years ago. The strategic planning process could provide a platform for faculty discussions of the challenges facing the department and the discipline. The process could also provide faculty members new to the department opportunities to help shape the future of the department.

PROGRAM REVIEW OUTCOME AND RECOMMENDATIONS FROM THE ACADEMIC PLANNING COMMITTEE

Review Outcome. The Academic Planning Committee, as a result of this review process, finds the M.S. in Chemistry program to be in Good Standing.

The Academic Planning Committee thanks the program for a concise and critical self-study report. The committee especially appreciates the thoughtful comparisons of the program with other graduate level chemistry programs in the state and nation and the conclusions faculty members have drawn from those comparisons. The committee finds particularly insightful the niche identified by faculty for the program: a research-oriented, thesis-based master's program for students not interested in or not yet ready for a doctorate in the field.

The committee commends faculty members of the Department of Chemistry for their contributions to the M.S. in Chemistry program through integration of their research with the curriculum and through one-on-one mentorship of students in the program. All tenure track faculty members in the Department of Chemistry are either graduate faculty members or, at the time of the self-study report, had applied for graduate faculty membership. Accordingly, all tenure track faculty members teach graduate courses, supervise and advise graduate students, and serve on thesis committees. Faculty members are active researchers who publish in international, peer-reviewed journals, often with students as co-authors. Faculty members involve graduate students in their scholarship through research groups limited to four graduate students each. The committee commends the department for its support of its graduate students through assistantships and through travel grants that enable students to present their research findings at regional, national, or international conferences. Faculty members have been recognized for their contributions to the discipline through honors such as the Illinois Professor of the Year award and recognition as a fellow in the Royal Society of Chemists. Graduate student contributions have been recognized as well, through the Fisher Thesis Award and numerous Outstanding University Graduate Teacher awards.

The committee recognizes contributions by chemistry faculty and students to area schools, museums, organizations, and community initiatives such as the Children's Discovery Museum, State Farm Millennium Girls Project, Army National Guard Civil Support, and Chemistry Olympiad. The committee also recognizes efforts by the department to engage corporate partners in curricular and co-curricular activities. The committee acknowledges mentorship of undergraduate students at the University by graduate students in the program through chemistry laboratories, laboratory/tutoring office hours, and participation with undergraduate students in co-curricular activities such as Chemistry Club and monthly symposia.

Despite a challenging fiscal environment, the department has maintained and upgraded equipment vitally needed for teaching and research through careful budgeting and grant procurement. Program faculty continues to work closely with Milner Library faculty to select resources most appropriate to the curriculum and to student and faculty research. Program and library faculty have also collaborated to teach information literacy skills students need to succeed in the discipline.

The self-study report articulates a desire to revise the student learning outcomes assessment plan for the program, noting a need to better align learning outcomes and assessment data collection with program goals and with assessment standards set forth by the accrediting body for the discipline (the American Chemical Society). The committee concurs. The committee asks faculty to revise the assessment plan and to implement the revised plan by collecting and analyzing data, utilizing findings to inform programmatic decisions, and documenting decisions made and the rationale for them. The committee asks the department to submit the revised assessment plan to the Office of the Provost by May 15, 2018, and to submit a report to the Office of the Provost regarding implementation of the plan by October 1, 2020. As faculty considers revisions to the assessment plan, the committee suggests that faculty consider further differentiating goals of the M.S. in Chemistry program from goals of the B.S. in Chemistry program. The committee also suggests that faculty consider incorporating direct measures of assessment other than course grades. The committee encourages faculty to develop a plan that can be sustained by the department given its faculty and staff resources. To that end, every student learning outcome need not be assessed every year nor is it necessary to evaluate the work of every student; staggering assessment of learning outcomes across multiple years and sampling student work are appropriate strategies. The committee recommends that faculty consider feedback provided by the Assessment Advisory Council and assistance available from University Assessment Services staff as it revises the assessment plan for the program.

Recommendations. The Academic Planning Committee makes the following recommendations to be addressed within the next regularly scheduled review cycle. In the next program review self-study, tentatively due October 1, 2024, the committee asks the program to describe actions taken and results achieved for each recommendation.

- The self-study report articulates the need for a new strategic plan to guide the department and its programs through the next program review cycle and beyond. With the department chairperson position now filled and with more than 12 years having passed since the previous strategic plan was adopted, undertaking a strategic planning effort is a prudent first action following program review. The committee views strategic planning as an opportunity for faculty members to address issues they have identified through the self-study process. The recommendations that follow could be addressed through the strategic planning process or through separate but related planning initiatives.
- In its self-study report faculty has identified several curriculum-related challenges that merit attention in coming years. The committee recommends addressing two in particular. One challenge is to devise a system for scheduling sub-discipline courses that better serves student interests and needs. Another is to assess the need for expanding emphasis in the curriculum on development of computer literacy, information literacy, safety, ethics, and oral and written communication skills to meet the changing needs of employers in the discipline.
- The self-study report states that enrolling female students and students who self-identify as persons of color continues to be a challenge for post-secondary chemistry programs across the nation, including the program at Illinois State. Efforts of the Department of Chemistry to promote diversity have resulted in a student body that is 46 percent female (as reported in the self-study report) and 15 percent non-white (which is the average across all graduate programs at the University). The committee encourages the department to continue its efforts to recruit for diversity across multiple dimensions (including, but not limited to gender and race/ethnicity) and to maintain a climate of inclusion for all students.
- The self-study report notes the challenges faced by program and library faculty to maintain access to journals and databases most needed for teaching and research in the department. Subscription rates continue to rise while funding for those subscriptions has been stable at best, necessitating difficult resource choices. The committee is concerned about this situation especially in light of the emphasis in the program on research. The committee recognizes the difficulties of addressing this concern and the reality that other disciplines at the University are facing similar challenges with regard to library resources. Nonetheless the committee encourages program and library faculty to maintain a prioritized list of journals and databases needed to support student learning and research for use in the event that additional budget reductions are necessary or additional funds for library resources become available. The committee further encourages program and library faculty to continue investigating alternative library resource funding strategies and resource delivery options, including, but not limited to, enhancing resource sharing across universities in the state, expanding per-use subscription services such as *Get It Now*, incorporating funding for library resources in research grant proposals, and seeking contributions to library funds by external entities (e.g., corporate partners).
- The self-study report describes extensive efforts by the department to document and communicate with program alumni through faculty outreach and use of social media. The committee commends these efforts. To help further develop alumni relations the committee recommends that the department investigate establishing an alumni advisory board. Such a board could provide input regarding curriculum design and student learning outcomes assessment, help students establish networks in the discipline and compete for jobs, guide the program and department with solicitation of external funding to support equipment and library resource purchases, and assist the department with student recruitment and retention efforts. With the Department of Chemistry having celebrated its 50th anniversary throughout 2016, interest among alumni in establishing an alumni board may be particularly high at this time.
- The committee recommends that, in support of its student recruitment and public outreach efforts, the Department of Chemistry continue to make publicly available information regarding research interests of each faculty member in the department and opportunities for faculty-student research collaborations. The Faculty/Staff and Research sections of the department website effectively communicate this information in a manner comprehensible to upper division undergraduate students, graduate students, and academicians but not necessarily to prospective undergraduate students or the general public. The committee recommends that the

department consider providing this information in a manner accessible and highly engaging to the latter populations as well.

- Beyond the work requested by the committee to revise the student learning outcomes assessment plan for the program, the committee encourages the program to nurture and sustain the feedback loop characteristic of a meaningful assessment process by utilizing information collected through student learning outcomes assessment to make program improvements and to document how that has been done.