

# Program Review Report

June 2017

1. **Reporting Institution** Eastern Illinois University
2. **Program Reviewed** M.S. in Chemistry (40.0501)
3. **Date** February 20, 2017
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## 5. Overview

The Master of Science in Chemistry program at EIU is intended to provide a strong foundation in Chemistry, that covers a breadth of chemical sub-disciplines, and which prepares students with both the hard and soft skills that are needed for success in Ph.D. programs and jobs in industry. The two year program includes course work in each of five main chemical sub-disciplines, as well as an intensive research project that leads to writing and defending a thesis.

The Chemistry M.S. program contributes to the mission of graduate education at EIU. Many Chemistry M.S. students are international students (in Fall 2017, 66% international students from 4 countries), adding internationalization and diversity to the university and the Chemistry department. All M.S. students are required to demonstrate depth of knowledge through required course work and the passing of an oral defense of their written thesis. The thesis and defense also promote oral communication skills, and these are enhanced by the additional 40 minute literature seminar presentation required of each M.S. student. Students participate in laboratory, lecture, and seminar-type course work, in addition to the central research experience of the degree program. They work closely with undergraduate students in faculty research labs, enhancing the experience of both the B.S. and M.S. students. B.S. students can also, with some advanced planning, complete both B.S. and M.S. degrees in 5 years. Research performed for the M.S. in Chemistry degree is often presented by graduate students at regional, national and international conferences, and results are published by faculty with student co-authors in peer reviewed journals. Many faculty are supported by external grants, which totaled \$1.96M from 2009 – 2016.

The student learning objectives of the program coincide well with the graduate mission and are that students will: (1) learn fundamental principles at an advanced level in selected areas in chemistry, and be able to (2) conduct original research, (3) communicate technical material effectively in speaking and writing, (4) properly utilize chemical information sources, and (5) critically analyze a breadth of chemical problems & experimental results.

## 6. Major Findings and Recommendations

- a. **Description and assessment of any major changes in the program/disciplinary context, e.g., (1) changes in the overall discipline or field; (2) student demand; (3) societal needs; (4) institutional context for offering the degree; (5) other elements appropriate to the discipline in question; and (6) other.**

(1) **Changes in the discipline:** The Bureau of Labor Statistics projects slow growth in chemistry and materials science over the 2014-2024 period, with predicted declines in manufacturing jobs that tend to employ chemists (Occupational Outlook Handbook). On

the other hand, the incoming presidential administration's seeming inclination to shun foreign manufacturing and workers could lead to an increase in demand for American-educated chemists. Interest in biochemistry and other health-related fields has increased greatly in recent years. This is partly a result of the recent addition of biochemistry content to the MCAT exam, making premed students more aware of biochemistry as a separate subject and leading them to take more courses that are not housed in Biological Sciences departments. In addition, health-related post-baccalaureate fields (Physician Assistant, Occupational Therapy, etc.) are growing rapidly. M.S. degrees in more traditional fields (Chemistry, Biochemistry, Biology) are becoming a common intermediate step for these students between their undergraduate and professional education.

- (2) **Student demand:** In 2008-2009 the department had begun to recover from the reduced numbers of applicants that resulted from the 9/11 attacks and resulting Patriot Act. We have had steady demand from Sri Lankan students, starting around 2008, and these applicants have been augmented by a (small) recovery in the number of Chinese applicants, and, since around 2014 there has also been steady interest from Nigeria. The over the 2009 – 2016 time period, 53% of enrolled and 53% of graduating M.S. students have been international students. Our ability to offer graduate assistantships to a select number of students helps us to attract some students who might otherwise attend different schools.

Since the M.S. program is research based, the capability of the program to accept students is somewhat governed by the research facilities and interests of the faculty. High levels of federal grant funding for research within the department have helped support additional graduate students without the need for GA's. Within Chemistry, demand for research experiences in Analytical and Inorganic/Materials chemistry is quite high. Despite being well staffed to teach courses in these areas, our research capacity for Materials and Analytical chemistry is very limited (one faculty member accepting students in each area).

- (3) **Societal needs:** The program fulfills a demand for US training that is needed by many international students prior to being sufficiently prepared to enter a Ph.D. program. The remaining 47% of Chemistry M.S. students at EIU who are US citizens typically have bachelor's degrees from US institutions and either need further training before applying to Ph.D. programs, desire careers teaching in community colleges, or wish to obtain jobs in industry, for which the added qualification of an M.S. degree will open positions of higher responsibility and pay. With the incoming presidential administration, it is expected that the number of highly qualified foreign scientists in the US will drop; thus, there will be a need for American scientists to fill vacant research, development, manufacturing and other technical jobs, and this may lead to increased demand for the Chemistry M.S. degree from domestic students. One departmental goal for the coming semester, arising from the recent Vitalization process initiated by President Glassman, is to address how best to market the Chemistry M.A. program to attract both well qualified domestic and foreign students.
- (4) **Institutional context for offering the degree:** Chemistry graduate students play a pivotal role in operation of the department. Graduate assistants (GAs) help supervise undergraduate lab classes, although this is done in close collaboration with faculty members so that there is a mentoring aspect to the experience. Having GA help for undergraduate labs is very cost effective, with more than one faculty member's worth of teaching credit units covered by GAs each semester. Graduate students in faculty research groups provide maturity and continuity, allowing a level of research to be

performed that would be difficult with only undergraduate students. The presence of the M.S. program in the department is beneficial for recruitment of undergraduate students and recruitment and retention of quality faculty. This program also helps us to acquire federal grant funds, which provide equipment and research experiences that undergraduates from all majors who take Chemistry courses benefit.

- (5) Other elements appropriate to the discipline:** Nearly concurrently with the last IBHE review in 2008 – 2009, the department updated our M.S. curriculum. We now require a core of four graduate courses (covering the five major chemical sub-disciplines) that have been designed specifically to cover important areas of chemistry that are not taught in the undergraduate curriculum. We feel that this distinguishes us from other programs where many graduate courses are simply a more in-depth treatment of the same material that would be covered at the undergraduate level. Graduate students also take a required course in reading, interpreting, and discussing peer reviewed literature, and team-building and laboratory skills have been incorporated in the Bioanalytical Problem Solving course that is part of the core curriculum. The central research experience and thesis based upon it have not changed, although we have significantly developed our assessment methods of the M.S. program, including the written thesis and oral defense, over the past ~5 years.

**b. Description of major findings and recommendations, including evidence of learning outcomes and identification of opportunities for program improvement.**

A variety of methods are used to assess student achievement of learning objectives. These include completion of assignments on certain topics, performance on entrance exams covering core chemical sub-disciplines, faculty/thesis-committee evaluations of performance on oral presentations, thesis defense and the written thesis, and responses on exit and/or alumni surveys. Students generally do very well on the course-work based assessments, with 100% of students meeting stated criteria in most cases. Performance on Chemistry placement exams is less successful. Although nearly 100% of students have scored well enough on placement exams to place into Analytical and Inorganic graduate courses, only ~60-80% of students have met the requirements for Physical and Organic chemistry. Our assessment plan initially intended for these exams to be re-taken when students leave the program, but this has proven very difficult to implement and thus has not worked well as a measure of student learning. The lower than expected scores of entering students indicate a need to recruit more highly qualified applicants, and this is a concern that is currently under discussion within the Chemistry department. Assessment of the central thesis/defense experience is accomplished with two surveys that are submitted by each thesis committee member for each student. These also show results that consistently fall slightly short, with critical thinking results appearing to be some of the worst. Data are only available for a few years for this assessment tool, and although in some years success was 100% on measures of critical thinking, there were other years with results in the 20-50% range. It is difficult to know how trustworthy these are, since faculty completion of the surveys is sporadic; however, we clearly need to work on emphasizing critical thinking in our graduate course work so that when students write and defend their theses, they have sufficient experience to achieve expected standards.

**c. Description of actions take since the last review, including instructional resources and practices, and curricular changes.**

Curricular changes, as well as changes to assessment procedures, implemented since the last review have already been discussed above.

The Chemistry M.S. program has recently developed links with several other programs on campus, and these help strengthen student numbers in graduate courses, as well as adding to the breadth of experiences that students bring to class with them. In graduate courses this is

particularly beneficial, as we aim to encourage students to make connections between topics and develop more advanced critical thinking skills. The presence of graduate students from Biological Sciences and from the recently launched Biochemistry and Biotechnology M.S. program within Chemistry courses adds diversity of knowledge and skills and benefits all students involved in the classes.

**Recent faculty hires:** The hiring of a faculty member with expertise in materials, and particularly with interests in solar cell development has allowed the department to build strong ties to the new CENCERE renewable energy center on campus. This faculty member was hired in 2012 and has already been successful in obtaining significant external funding for his research program, and he has an active research program involving both undergraduate and masters students. An additional hire of a biochemist in 2010 replaced a faculty member who failed to achieve tenure. This biochemist also has been successful at obtaining external funding for her research and has an active undergraduate and graduate research program.

**Instructional resources:** The department was the victim of a major vandalism attack in November 2011. This resulted in destruction of all of the major instrumentation in the department, many computers, and significant numbers of samples and equipment in faculty research labs. The department was able to rebound from this setback relatively quickly, thanks to the support of the EIU administration for facilitating many large equipment orders very quickly. Ultimately, a few classes had to be taught differently than usual during the Spring 2012 semester, but operations were back to normal by Fall 2012. In addition to replacement equipment obtained as a result of the vandalism losses, we have continued to modernize equipment used in lab classes. The department upgraded its computational resources to a 12 CPU Linux workstation running state of the art computational chemistry software in Spring 2013, and this and PC versions of the software are used at multiple curricular levels.

**d. Description of actions to be taken as a result of this review, including instructional resources and practices, and curricular changes.**

As a result of the institution wide Vitalization that took place in Fall 2016, along with anticipated significant faculty turnover in the next few years (resulting primarily from uncertainty about the state budget stalemate), the Chemistry department is intending to develop a long-range plan for the next 5-10 years during the Spring 2017 semester. We will investigate ways to share resources (physical or virtual) with similar institutions in the state, where similar concerns over budget exist. We will revisit our recruiting plan, with an emphasis on recruiting well qualified domestic students, since the future of international students in the US is highly uncertain.

**7. Responses to Institution-Assigned Issues**

**a. What strategies has the department implemented that will support the Integrative Learning Experience at EIU?**

Research, which is the central experience of all Chemistry M.S. students is highly integrative; however, here we can also mention two additional course-based experiences that are central to the Chemistry M.S. experience and that are highly integrative. The Chemistry M.S. degree includes a required "Graduate Seminar", CHM5001, in which a student must choose a topic from peer reviewed literature, study and understand the literature and find supporting additional sources, and then present a 40 minute seminar to Junior, Senior and Graduate students and Chemistry faculty. This requires students to apply knowledge from many different areas of chemistry as well as their skills in literature searching and oral communication. In addition to requiring deep comprehension of chemical literature at a level that is not necessarily needed even to write the thesis, this also serves as a "warm-up" to the thesis writing and seminar, where literature searches and oral expression are again significant. A second course that was introduced with the recent

graduate curriculum revision is “Reading the Chemical Literature”, CHM5003. This focuses on integrating skills and knowledge from course work to understand papers on topics that were *not* chosen by the student – i.e. how to use your knowledge base to understand something that is totally different from your usual specialty or comfort zone. Over the course of the semester, students must critique papers both orally and in writing, as well as leading at least one discussion on a paper.

**b. What one unique, noteworthy activity is the department involved in that will enable the IBHE to distinguish its program from other similar programs in the state?**

The importance of graduate scholarship to the Chemistry department cannot be overemphasized. Many faculty are performing quality research with graduate students, but the work of Dr. Hongshan He stands out. Dr. He has supervised six graduate students in his 3.5 years at EIU. His extraordinary success at obtaining external funding (with grants from both the National Science Foundation and the Petroleum Research Fund) has allowed him to support several of these students on research assistantships during the school year and summer. Chemistry graduate students Prasadini Senevirathne has been particularly successful working in Dr. He’s lab and she presented her work at the American Chemical Society National Meeting in Philadelphia in August 2016. Prasadini also acted as a mentor to an undergraduate student working in Dr. He’s lab during Summer 2016 and she will have her results published in top journals.

**8. Responses to Institution-Assigned Issues**

**8.1 Decision:**

- Program in Good Standing  
 Program flagged for Priority Review  
 Program Enrollment Suspendended

**8.2 Explanation**

Dean Comments

With the State of Illinois budget stalemate, EIU enrollment decline and anticipated faculty reduction, and probable difficulty in enrolling foreign national students in the near future, this program faces fundamental challenges. Never-the-less it is instrumental to the Department of Chemistry and Biochemistry’s current mission and aligns with the mission of EIU. I support the department’s investigation of creative ways to maintain the program’s viability.

Provost’s Comments

During the University’s recent Vitalization Initiative, this program was initially identified as a program that should be considered for elimination. Following careful review by the President’s Council, the program was removed from such consideration in recognition of the success in securing extramural research funding, and its contributions to a number of other graduate programs at Eastern. The dean’s observation that that Department will need to be creative in finding new ways to maintain the program’s viability.