Millikin University
Student Learning in the Chemistry Major

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Executive Summary

The Department of Chemistry supports the mission of the university in preparing students for professional success, democratic citizenship in a global community, and a personal life of meaning and value by producing graduates who achieve the following three chemistry-specific learning outcome goals:

1. Demonstrate the skills to solve problems and communicate through writing and speaking.

2. Discover how to integrate and apply knowledge and skills both within the chemistry community and between chemistry and other disciplinary communities.

3. Develop the capacity to address real-world scenarios in which chemistry plays a role.

Our curriculum introduces each student to the five sub-disciplines of chemistry recommended by the Committee on Professional Training of the American Chemical Society (ACS-CPT). The chemistry curriculum incorporates the integration of theory and practice. Theory is emphasized in classroom activities while practice is emphasized in the laboratory. In some cases, courses tightly integrate the two. Every student majoring in chemistry completes a core curriculum. Depending upon their individual interests, students then select additional study in one of four areas that we call emphases: research, secondary education, biochemistry, or business.

Regardless of emphasis, undergraduate research is the capstone of the chemistry major at Millikin. Students in the Department of Chemistry demonstrate Performance Learning in the three stages of an undergraduate research project: proposal, performance, and presentation. This activity requires the synthesis of all three learning outcome goals and therefore is the easiest to assess uniformly. Excellent undergraduate research characterizes excellent chemistry programs.

We created a rubric for assessing each component of undergraduate research: proposal, performance, and presentation (oral and written). **Based on these rubrics, we rate our current status on all three learning goals as acceptable**. We will work on ways to ensure that all our students continue to perform at an acceptable level in the future.

Report

Performance Learning

Millikin students thrive through our unique approach to Performance Learning. In addition to a solid foundation in the theory of a given field, Millikin students gain practical, hands-on experience in their fields of study. Students in the Department of Chemistry demonstrate Performance Learning in the three stages of an undergraduate research project. Our students learn how to plan and communicate their plan for research by writing a proposal. They learn to conduct research by performing research. They learn how to communicate their results through written and oral presentations. We want our students to learn how to do chemistry the way chemists do it. We accomplish this goal.

The culmination of Performance Learning for students in the Department of Chemistry is presentation of their research to an external audience. Four chemistry majors graduated this May. One major completed the degree requirements in December 2017 even though he walked during the Spring 2017 commencement. One junior chemistry major presented his research at the National Conference on Undergraduate Research, the Illinois State Academy of Sciences Meeting, and the Midwestern Association of Chemistry Teachers at Liberal Arts Colleges Annual Meeting. Five students presented their research at the 2018 Millikin University Undergraduate Research Poster Symposium, and three received awards for their posters, including two second place awards and a third place award. Two posters describing interdisciplinary projects involving chemistry, physics, and business majors were presented at the American Physical Society March Meeting. One of the collaborative posters was also presented at Millikin's Undergraduate Research Poster Symposium. This poster earned a third place award from the institution.

The Department of Chemistry further supports the institutional mission by preparing students for professional success, democratic citizenship in a global community, and a personal life of meaning and value. The mission of the department is to produce graduates who achieve the three learning outcome goals listed on page 1. The successful graduate of the Department of Chemistry is not necessarily a professional chemist. For example, recent graduates are working in the chemical and pharmaceutical industry, practicing medicine or pharmacy, selling technical goods and services, running their own businesses, teaching, and working in the areas of government and law, among other things. We are pleased to report that 100% of the 2018 graduates are or will be using their degrees professionally. Two alums are employed as professional chemists, one at Akorn Pharmaceuticals and one at Archer Daniels Midland Company. The other two graduates will start pharmacy graduate programs at Southern Illinois University, Edwardsville this fall.

Snapshot

Faculty and Staff

The American Chemical Society Committee on Professional Training (ACS-CPT) approves of the Department of Chemistry and its curriculum. The department consists of five full-time faculty members representing the five major sub-fields of chemistry: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry.

The Department of Chemistry hired adjunct instructors to cover ten courses during AY2018, a 2.5 FTE. The University employs a full-time administrative assistant that works up to 15 hours per week supporting our department. We also hired one individual to cover nine hours of laboratory prep per week during the spring 2018 semester. Laboratory prep for all first year laboratory courses (CH114, CH151, CH152, and CH205) carries a significant time commitment (greater than 20 hours per week) that was shouldered by Dr. Paris Barnes and Chelsea Hadsall.

Curriculum

The 2018 academic year (AY2018) included changes in our course offerings. CH114 (Fundamentals of Chemistry) was offered for the first time. This course focuses more on the chemistry and techniques associated with clinical situations and directly feed into CH203/205 (Essentials of Organic and Biochemistry with lab). Nursing and athletic training majors constitute the primary audience for CH114. CH114 served 107 students, including students majoring in nursing, athletic training, exercise science, and exploratory studies, *inter alia*. Inclusion of CH114 reduced enrollments in CH121 (General Chemistry) and CH151 (Introductory Chemistry Lab I) to 57 students. One goal was to reduce student attrition in our general chemistry courses by encouraging non-natural science majors to enroll in CH114. Ideally, the majority of students who took CH121 were science majors and at least co-enrolled in MA110 (College Algebra). Students withdrew from CH121 15.7% (or 19 of 121 enrolled students) of the time during the Fall 2016 semester. After the addition of CH114, the CH121 student withdraw rate decreased slightly to 14%. Only 10.2% of the students enrolled in CH114 during AY2018 withdrew, lowering the overall withdrawal percentage in CH121 and CH114 to 11.5% (or 19 out of 164 students).

CH203/205 have enrollments between 90 and 110 students yearly. The same student cohort who completes CH114 primarily takes CH203 and CH205. CH224 (General Inorganic Chemistry), CH301/302 (Organic Chemistry I and II), and CH331 (Biochemistry) courses each serve approximately 15-45 students per year, primarily chemistry and biology majors. The following courses are taken almost exclusively by chemistry majors: CH232/253 (Analytical Chemistry with lab), CH254 (Introduction to Research), CH303/304 (Physical Chemistry I and II), CH351 (Advanced Lab I), CH353 (Advanced Lab III), CH420/352 (Instrumental Analysis with lab), and CH482 (Senior Seminar). Enrollments vary from year to year based upon the number of chemistry majors in a given cohort. Unfortunately, multiple 200- and 300-level courses with

enrollments below four students were canceled during AY2018. CH232 (Analytical Chemistry), CH253 (Intermediate Lab III), CH304 (Physical Chemistry II), CH351 (Advanced Lab I), and CH353 (Advanced Lab III) were the casualties of enrollment issues.

Another curricular change that was implemented requires students in the biochemistry and business emphases to take CH420/CH352 (Instrumental Analysis). Advanced instrumentation is playing a greater role in all areas of chemistry. Furthermore, past senior exit interviews revealed that too many of our majors were graduating with the knowledge of how to operate the instruments but with little understanding of how the instruments actually work.

American Chemical Society Committee on Professional Training Degree Certification; Required Curricular Improvement

As part of this snapshot, we strive for academic improvement, in part, because the American Chemical Society's Committee on Professional Training approves our curriculum. We submitted a five-year comprehensive report to the ACS-CPT in June 2016. The committee's letter received in September 2017 reported that department's curriculum was not in compliance with the guidelines for awarding the ACS-certified Bachelor of Science degree in Chemistry. The areas the department must address include a foundation course requirement and a laboratory hour requirement. Evaluation of the spring 2016 CH224 syllabus and examinations by the ACS-CPT Review Board led them to conclude that the course fits the description of a second general chemistry course and was not a foundational inorganic chemistry course. The Review Board also subtracted the 45 hours associated with CH152 (Introductory Chemistry Lab II) from the in-lab hours we reported since this course was considered a general chemistry lab. Institutions awarding ACS-certified degrees must require students to complete 400 laboratory hours beyond the general chemistry level. Our curriculum continues to be approved by the ACS-CPT, but we must rectify the infractions outlined in the letter by June 2019 to maintain approval.

Engagement

Students can only thrive when an active and engaged faculty mentors them. Fortunately, that is the case in the Department of Chemistry. Two years ago, Dr. Timothy Guasco was awarded a grant from the American Chemical Society Petroleum Research Fund that is currently being used to support two research students financially. Dr. Guasco recently submitted a manuscript for review to the *Journal of Chemical Physics* with two Millikin student co-authors. Dr. Kyle Knust was awarded a $10,000 instrument grant from Pittsburgh Conference Memorial National College Grants program that supported the purchase of an instructional atomic force microscope. Dr. Anne Rammelsberg successfully ran chemistry camps for high and junior high school students at Millikin over the last three years. Dr. Rammelsberg and Dr. Paris Barnes accompanied two students to the 2018 Sigma Zeta National Convention. Dr. Barnes attended the American 2018 Physical Society March Meeting. Dr. Barnes and Dr. Knust earned institutional Summer Undergraduate Research Fellowships to support two

research students. Dr. Barnes, Dr. Guasco, and Dr. Knust are working with two Leighty Scholars and two Chemistry Fellows this summer. We are continuing our tradition of excellence in teaching, research, and educational outreach that is hallmark of our department.

Graduation Rates

In the decade from 2008 to 2018, approximately nine majors per year graduated with chemistry degrees. Five students graduated with a Bachelor's degree in chemistry during AY2018.

The Learning Story

Three hallmarks characterize the typical learning experience provided through the chemistry major:

1. **Doing chemistry as chemists do it.** Students use modern instruments from the first lab class in the first year; repeating experiments should be normal, not remedial. The desired outcome of an experiment is an accurate, reproducible, unambiguous result, not a predestined "right one."

2. **Modern chemistry is integrated.** Chemists address problems with concepts and techniques that span the various sub-fields of chemistry. Moreover, biologists, nurses, psychologists, and physicians also regularly use these same concepts and techniques.

3. **The main goal of laboratory experiences is tackling new problems capably.** We design experiments to develop maximum independence, not maximum coverage.

The curriculum map is included as Appendix 1. Our core curriculum introduces each student to four of the sub-fields of chemistry while providing a foundation in essential laboratory techniques. The additional courses in each emphasis then offer students more specialized technical training. Regardless of emphasis, undergraduate research is the capstone of the chemistry major at Millikin. It has three components, including the proposal, the research, and final written and oral presentations.

The proposal is part of CH254, Introduction to Research. A student must write the proposal on a project supported by a faculty member or an industrial mentor (with consent of a faculty member). The proposal includes a background section that shows careful reading of primary journals. Ideally, the research should be connected to a real-world problem.

In terms of the actual research, we look for consistent work over time. The student should try to do a project that might be presented at a meeting, especially the National Meeting of the American Chemical Society. The lab notebook is assessed to

determine the quality and quantity of work. The best projects generate previously undiscovered knowledge.

In CH482 (Senior Seminar), the student writes the final report and presents the work orally. This presentation includes an explanation of the context of the work, the techniques used, the data, and an interpretation of what the results mean. The student is also expected to reflect on what he or she learned about chemistry in the process.

Just as the curriculum helps the department achieve goals for student learning outcomes and helps students actualize their plans of study, so too does the advising process. Advising in the Department of Chemistry facilitates and integrates reasoned choices that promote the student's growth as a person and as a major. In order to realize this mission, we try to help students:

1. Develop plans of study for successfully achieving their degree and career goals,

2. Select courses each semester to progress toward fulfilling their plans of study,

3. Use the resources and services on campus to assist in fulfilling their plans of study, and

4. Graduate in a timely manner.

Students meet with their academic advisors at least once per semester to discuss fulfillment of the plan of study.

Assessment Methods

We decided that assessment of the three stages of undergraduate research is the most informative way to assess the three learning outcome goals. The research project is the culminating event of each goal as well as the climax of each emphasis within the major. We have created rubrics for assessing the proposal, performance, and presentation of research. These rubrics are included in Appendix 2.

Assessment Data

Department Learning Goal 1 will be assessed in CH482 using the final presentation rubric. Learning Goal 2 will be assessed in CH254 using the proposal rubric. Learning Goal 3 will be assessed in CH391/491 using the research rubric.

As noted above, department learning goals are assessed by evaluating student learning in specific classes. Five to 10 students from each class will be randomly selected for evaluation. As a general rule, one-half of a given class will be selected; for classes with fewer than 5 students, all students in the class will be evaluated; for classes with greater than 20 students, 10 will be randomly selected.

The grading rubrics used to assess each learning goal have three categories: Excellent, Adequate, and Nominal. The range of points possible on each rubric is 2-14. A student ranked adequate on all evaluative items would have a numeric score of 8. All students should be ranked adequate (i.e., have a minimum score of 8 on each rubric) if the department goals are being achieved. Realistically, however, there may be students, for a variety of reasons, who are ranked less than adequate. Considering the small sample sizes typically available in a given class, the following assessment criteria will therefore be used to evaluate student progress in achieving department learning goals.

Green (an acceptable level or clearly heading in the right direction and not requiring any immediate change in course of action): 80% or more of the students ranked adequate or excellent;

Yellow (not an acceptable level; either improving, but not as quickly as desired or declining slightly. Strategies and approaches should be reviewed and appropriate adjustments taken to reach an acceptable level or desired rate of improvement): 60% to 79.9% of the students ranked adequate or excellent; and

Red (our current status or direction of change is unacceptable. Immediate, high priority actions should be taken to address this area): fewer than 60% of the students ranked adequate or excellent.

For reporting purposes, a rubric numeric score of 13-14 will be considered excellent; a score of 8-12 will be considered adequate; and a score less than 8 will be considered nominal. Assessment data are listed in the tables below.

Table 1. Assessment of student performance with respect to Department Learning Goal 1, demonstrating the skills to solve problems and communicate through writing and speaking.

Rubric category	Percentage of students in category
Excellent	20
Adequate	60
Total of above (used for rating)	80
Nominal	20
Number of students evaluated	5
Average numeric score	10.0

Rating for Learning Goal 1: **Green**

Table 2. Assessment of student performance with respect to Department Learning Goal 2, discovering how to integrate and apply knowledge and skills both within the chemistry community and between chemistry and other disciplinary communities.

Rubric category	Percentage of students in category
Excellent	57
Adequate	43
Total of above (used for rating)	100
Nominal	0
Number of students evaluated	7
Average numeric score	11.7

Rating for Learning Goal 2: **Green**

Table 3. Assessment of student performance with respect to Department Goal 3, developing the capacity to address real-world scenarios in which chemistry plays a role.

Rubric category	Percentage of students in category
Excellent	40
Adequate	40
Total of above (used for rating)	80
Nominal	20
Number of students evaluated	5
Average numeric score	10.4

Rating for Learning Goal 3: **Green**

Table 4. Year-to-year comparisons of assessed student performance with respect to the three Departmental Learning Goals. Rating percentage is the percentage of students with earning at least an acceptable rating with respect to the Learning Goal. Ratings: ≥80% = green; ≥60% - <80% = yellow; <60% = red.

Year		2013	2014	2015	2016	2017	2018
Learning Goal 1	Rating percentage	100	75	100	80	100	80
	Color rating	**Green**	**Yellow**	**Green**	**Green**	**Green**	**Green**
Learning Goal 2	Rating percentage	100	100	100	100	100	100
	Color rating	**Green**	**Green**	**Green**	**Green**	**Green**	**Green**
Learning Goal 3	Rating percentage	62.5	80	100	100	100	80
	Color rating	**Yellow**	**Green**	**Green**	**Green**	**Green**	**Green**

Analysis of Assessment Results

Student learning for all three of our learning goals was assessed at the **green** level (an acceptable level or clearly heading in the right direction and not requiring any immediate change in course of action) for AY2018. This is the twelfth consecutive year in which student performance associated with Learning Goal 2 has been rated **green**. This is the eleventh time in 12 years in which student performance associated with Learning Goals 1 and 3 has been rated **green**. Although we are pleased with these results, we view them as still having room for improvement. As we have done in every year since we began the assessment process, we have made and continue to make conscious efforts to improve student learning.

Although our seniors demonstrated stronger writing skills than recent classes, we continue to observe that the quality of student writing remains unsatisfactory across the board. We recognize that despite the positive assessment of student learning, this is one area where we must and will continue to work with students to strengthen their skills.

While we are pleased that the majority of our students achieved an acceptable level of learning on all three of our learning goals, we know that we cannot rest on our laurels. We continually evaluate our curriculum, keeping two questions foremost in our evaluation:

1. Are we delivering a quality education to our students?

2. How well do our students learn?

Quality

We are confident in the quality of our program. Our program is accredited by the ACS-CPT, the benchmark of a quality chemistry program. Our graduates leave Millikin and go on to successful and distinguished professional careers. Of the four recent graduates, two are going onto pharmacy graduate programs and two are gainfully employed in industry. Furthermore, Zippia, a career advice website dedicated to helping recent college graduates with their career choices, named Millikin's Department of Chemistry the seventh best among four year institutions in Illinois for chemistry majors with respect to career opportunities. We know our students gain a quality education that prepares them for professional success.

Feedback from the students we serve is essential to maintaining and improving program quality. We conduct exit interviews with each of our graduating seniors as part of CH482, Chemistry Senior Seminar. We ask students to be prepared to discuss the following seven questions:

1. What will you be doing one year from now?

2. What will you most remember about your experience as a chemistry major five years from now?

3. What, if anything, would you do differently if you had to complete your degree all over again?

4. How would you advise a new chemistry student?

5. What are the strengths of the chemistry program?

6. What aspects of the chemistry program need improvement?

7. Did you feel as though you "belonged" in the department? Why or why not?

We encourage our students to be open and honest in their responses to our questions, reinforcing the idea that one of the ways we can improve as a department is through their feedback. The overall message we continue to receive from students is "keep doing what you have been doing." Students commonly tell us that the department's main strength is its faculty. All of the full-time professors and many of the adjunct faculty are considered knowledgeable, willing to help, and frequently available to our students. Our students also stated that the coursework was difficult, but they feel it prepared them for future success in their chosen professions.

Students often offer specific suggestions for improvements in the department, which we take seriously. Unlike previous years, modern instrumentation was a lesser concern largely because many of the aging instruments have been replaced over the last three years. Modern and up-to-date instrumentation supports a contemporary chemistry curriculum. Dean Randy Brooks requested and received the Department of Chemistry's Modernization report in January 2013. Then-Department Chair Dr. George Bennett stated the department's infrastructure for supporting Performance Learning was declining, and was uncomfortably close to being unsuitable for research and teaching activities. He wrote:

> The replacement costs of [...] equipment [...] range from $3000 to $180,000, with most in the range of $30,000-60,000. When an instrument needs to be repaired, the campus visit from the service technician alone costs $1500. The Business Office does not permit us to roll over unspent funds in our department budget from one fiscal year to the next, so we do not have the ability to build an account for new equipment purchases. Information Technology (IT) does not support computer hardware and software that is associated with lab instrumentation. The University's support for external grants through matching funds is not so robust as it used to be. For us to attain yellow status, the University would have to commit to an equipment replacement cycle similar to the computer replacement cycle that IT follows for office computers. To attain green status, the University would have to commit to helping us acquire *and maintain* instrumentation that we do not currently have, such as a fermentation reactor, a microwave reactor, an inductively

coupled plasma spectrometer, a Raman spectrometer, or thermal analysis equipment, among others.

As of this writing, several of the needs outlined in the Modernization Report have been addressed. Instrumentation modernization is largely attributed to Dr. Knust, the institution's administration, and our industrial partners. Dr. Knust replaced our aging gas chromatograph with a refurbished one. Part of the funding for this instrument came from trading our antiquated and unusable items to a company for credit. He also successfully received a $10,000 grant from PITTCON toward the purchase of an atomic force microscope. The matching funding ($15,000) for the new instrument was provided by the Department of Chemistry. ADM donated refurbished thermal analysis equipment (i.e., a thermogravimetric analyzer and a differential scanning calorimeter) to our department that was received during AY2018. Akorn Pharmaceuticals donated an ion chromatography instrument to the department. The differential scanning calorimeter and ion chromatography instruments are neither functional at this time. Both instruments will require additional financial resources and time to get them operating.

However, some of our instrumentation still has problems. Our recent graduates expressed frustration with using the instrumentation primarily associated with Organic Chemistry. The department's NMR and FTIR are high throughput instruments, averaging well over 200 uses per year. Both instruments exhibit the effects of frequent use. While we greatly appreciate the support of the University in recent years, allowing us to acquire new instruments for both teaching and research use, we ask the institution to recognize that ongoing maintenance and upkeep is a significant investment. Furthermore, the inability to save funds remaining in the department budget at the end of the fiscal year for several years severely handcuffs our ability to purchase new instruments and replace older ones. In order for the department to continue delivering a high quality educational program to our students, two actions need to happen. First, the level of annual support from the University for instrument repair and maintenance must dramatically increase. Second, we recommend that the institution review how end-of-year financial surpluses are handled. The ability to accumulate unspent budget funds would allow us to procure one new major instrument every three years.

Learning

In addition to the Learning Goals described in this report, we also use additional measures to assess student learning in the chemistry program. We continually monitor and evaluate these measures of student learning. We monitor the quality of our students' writing on formal laboratory reports, research proposals, and research reports. We see a downward trend in the quality of writing by our students as a whole over the last year. This situation is not unique to chemistry, but is troubling nonetheless. We encourage students to take advantage of the resources available at Millikin's Writing Center, and mentor students one-on-one.

We administer standardized exams such as those developed by the American Chemical Society's Examinations Institute and the Educational Testing Service Major Field Test in Chemistry. We find that our students typically score below the 50th

percentile on such standardized exams. We view the standardized exams as one measure of our students' long-term learning, and are concerned with the relatively poor performance of our students on these exams. We will continue to devote time and effort to improving our students' long-term learning while still maintaining their excellent showing on our learning goals.

Improvement Plans

Three areas of improvement have been identified: (1) Addressing the ACS-CPT response to our five-year report; (2) Developing better scientific writing skills; (3) Improving retention of knowledge by our students.

In the coming months, we must address the two infractions highlighted by the ACS-CPT report. Currently, CH224 does not satisfy the Committee's requirement as a foundational inorganic course, and students attempting to complete ACS-endorsed degree are not required to complete the minimum 400 lab hours beyond the first year lab courses. There are multiple proposed solutions to the foundational inorganic chemistry course, including adding a second semester general chemistry course and retooling CH224 to be a true first inorganic chemistry course. One possible solution for the lab hour requirement is requiring students pursuing the ACS-endorsed degree to complete CH354, Biochemistry Lab.

Second, in the previous section, the decline in writing quality by our students was noted. We acknowledge that written communication is difficult, but we provide ample opportunity for improvement. Students completing the Introductory Chemistry Labs (CH151 and CH152) complete developmental writing assignments and two complete lab reports. Both peers and instructors review drafts of the full lab reports. We ask our students completing Intermediate Labs I and II (CH251 and CH252) to write one partial lab report per semester as well. Partial laboratory reports in CH251 and CH252 focus on experimental results and their implications. Students are also required to complete multiple lab reports in the Advanced Chemistry Labs (CH351, CH352, and CH353) and Biochemistry Lab (CH354). The approach to writing in these courses includes iterative instructor feedback with opportunities for the students to improve their reports multiple times. Students write full research proposals in consultation with their advisors as part of Introduction to Research (CH254). Written student proposals are also subjected to peer, instructor, and research advisor review. Finally, students also write a complete final research report as part of Senior Seminar (CH482). The only lab course that does not include scientific writing is Intermediate Lab III (CH253) because it focuses on laboratory technique and accuracy of numerical results. We need to continue looking for new ways to encourage students to improve their scientific writing.

The final area we will continue to improve on is students' knowledge retention. Standardized exams with nationally normed data are our primary tool for the summative assessment of long-term learning. For example, we administer the respective ACS examination at the ends of CH224 (General Inorganic Chemistry), CH232 (Analytical Chemistry), CH302 (Organic Chemistry II), CH303 (Physical Chemistry I),

CH331 (Biochemistry), CH406 (Advanced Inorganic Chemistry), and CH420 (Instrumental Analysis).

We administer the ETS Major Field Test in Chemistry in CH482 (Senior Seminar). The ETS exam is scored on a scale of 120-200. As of the 2017 Major Field Test Comparative Data Guide for the Major Field Test in Chemistry, students earning scores 148 or greater score at or above the 50th percentile. We set 140 as the passing level, which is equivalent to the 26th percentile. We require our students to take the exam for the first time within four weeks after the course has started. If a student did not pass the test on their first attempt, he or she is asked to work with a faculty member on remedial proficiencies before taking the exam a second time. If students did not pass the exam on their second attempt, the cycle was repeated, and students were allowed to take the exam up to three times. Student results were as follows:

Table 5. Passing scores vs. number of attempts on the ETS Major Field Test in Chemistry between 2012 and 2018.

Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Number of students passing on 1st attempt	4	8	5	4	5	5	2
Number of students passing on 2nd attempt	1	2	0	2	2	2	2
Number of students passing on 3rd attempt	0	1	2	1	0	0	0
Number of students not passing	1	2	1	3	0	1	1

Table 6. Percentile rank earned by individual students on different sections of the ETS Major Field Test in Chemistry for 2018. There are not specified scores for biochemistry on this exam; however, questions related to biochemistry are included as part of the organic chemistry section.

Student	**Physical**	**Organic**	**Inorganic**	**Analytical**
1	41	47	45	44
2	56	42	54	41
3	41	47	48	41
4	53	53	38	44
5	33	45	38	31
Institution Averages	44.8	46.8	44.6	40.2
National Averages	49.8	48.7	49.2	48.4

Table 5 shows that 80% (or 4 of 5) of the CH482 students passed the ETS exam this year, and a majority of five passed on the first or second attempts. In fact, the two students who completed the exam on the second try nearly passed on the first attempt with scores of 137 and 139. A total of 57 students completed this exam over the last seven years. Approximately 57.9% completed with a 140 or higher on the first attempt, 19.3% completed the exam on the second attempt, 7.0% earned at least the minimum score after the third attempt, and 16.8% did not pass.

Table 6 shows that our students perform almost equally in the four chemistry sub-disciplines. While we do not teach to the test, we have devoted more energy across the curriculum to better prepare our students for these exams. We realize that achieving a 100% passing every year is unrealistic. However, inclusion of materials from other sub-disciplines of chemistry (e.g., discussion of how experimental techniques commonly used in organic chemistry can be applied to inorganic compounds; inclusion of a physical chemistry description when discussing spectroscopic techniques in analytical chemistry and instrumental analysis) should improve retention of previously learned concepts. Students need to see concepts multiple times in a variety of ways to truly understand them.

Summary

An approved curriculum by the ACS-CPT; adequate facilities with improving instrumentation; a dynamic curriculum that evolves to meet the needs of our students; faculty who desire to improve course offerings based upon feedback from external evaluators; students demonstrating Performance Learning; an active and engaged faculty. What does it add up to? Coupled with information from the Career Center stating our graduates have comprehensive success rate of 100% from 2004–2017, the Department of Chemistry continues to thrive.

Appendix 1: Curriculum Map for Chemistry

Department Learning Goals

1. Demonstrate the skills to solve problems and communicate through writing and speaking.

2. Discover how to integrate and apply knowledge and skills both within the chemistry community and between chemistry and other disciplinary communities.

3. Develop the capacity to address real-world scenarios in which chemistry plays a role.

Curriculum Map (Lecture/Lab) (**Bold** = Chemistry core courses)

Year	Department Goal 1	Department Goal 2	Department Goal 3
1	CH121 or CH131/**151** **CH224/CH152**		
2	**CH232/CH253** **CH301/251** **CH302**/CH252		
3	**CH303**/CH351 CH304 CH432	**CH254** CH331/CH354	**CH391 – 392**
4	CH353 CH406 CH420/CH352 **CH482**	**CH482**	CH470 **CH491 – 492**

Appendix 2: Evaluation Rubrics for Undergraduate Research

The proposal: grading done by faculty member teaching Introduction to Research.

	Excellent	Adequate	Nominal
Process	**[5 points]** A thorough explanation of previous work to a clear study question followed by analysis of previous work to synthesis into a coherent proposal.	**[3 points]** Shows some evidence of the process: explanation to conjecture to analysis to synthesis but incomplete.	**[1 point]** Restates some general ideas or issues but shows no evidence of analysis.
Connection	**[3 points]** A good proposal has a history. This includes your personal experience, it has a real-world context, and it has a connection to previous work both at Millikin and in the literature.	**[2 points]** Shows you understand the history of the proposal by examining some of your own experiences in the past as they relate to the proposal but otherwise incomplete.	**[1 point]** Minimal connections made.
Readings	**[4 points]** In-depth synthesis of thoughtfully selected aspects of readings related to the proposal. The readings are significant and appropriate at the college level. While you may use data and primary texts collected from the internet, the majority of readings are from library sources. Makes *clear* connection between what is learned from readings and the proposal.	**[2 points]** Goes into more detail explaining some specific ideas or issues from readings related to the topic. Makes general connections between what is learned from readings and the topic.	**[1 point]** You show some evidence of reading about the topic and are able to state some general ideas or issues from readings related to the topic. But there is no evidence of library research beyond the class textbook, secondary sources and the internet.
Grammar	**[2 points]** No spelling or grammar errors.	**[1 point]** Few spelling and grammar errors.	**[0 points]** Many spelling and grammar errors, use of incomplete sentences, inadequate proof reading.

Research: evaluation by faculty mentor using notebook.

	Excellent	Adequate	Nominal
Quantity	**[5 points]** You work consistently over the entire research period with clear evidence of significant weekly work. You consistently report to faculty mentor.	**[3 points]** You work consistently most of the time but miss from time to time	**[1 point]** You try to cram the work into a short period
Quality	**[3 points]** You work efficiently with some measure of success. Your work is worthy of submission to an off-campus conference	**[2 points]** You have some success but not at the level worthy of an off-campus conference	**[1 point]** Work is not worth crowing about.
Notebook	**[4 points]** Notebook is clearly written and contemporaneous.	**[2 points]** Notebook is contemporaneous but hard to follow.	**[1 point]** Your notebook is incomplete and a mess.
Safety	**[2 points]** You consistently use safe practice and clean up your work area.	**[1 point]** You consistently use safe practice but leave a mess behind.	**[0 points]** You work in an unsafe manner.

Final Presentation: written and oral report of results

	Excellent	Adequate	Nominal
Report	**[5 points]** A report having quality that might be submitted to a research journal. Includes background, data and methods, results, and discussion. Includes suggestion for further work.	**[3 points]** A good report but missing some aspect of an excellent report	**[1 point]** A report having minimal value
Oral Presentation	**[5 points]** Clear, confident presentation. Audience questions are answered in a way to illustrate a complete knowledge of the topic.	**[3 points]** A good presentation but lacking clarity or confidence.	**[1 point]** An awkward, weak presentation but a presentation made nevertheless.
Reflection	**[2 points]** A valuable reflection on the complete undergraduate chemistry experience.	**[1 point]** Some attempt at reflection but incomplete	**[0 points]** No reflection
External presentation	**[2 points]** Presented results at an off-campus conference or meeting	**[1 point]** Presented a good poster at the Millikin undergraduate research symposium	**[0 points]** No presentation

Appendix 3: Student Learning Evaluation Forms

Millikin University
Department of Chemistry
Student Learning Evaluation

Evaluation of: Department Goal 1.
"Demonstrate the skills to solve problems and communicate through writing and speaking."
Item evaluated: Final Presentation (written and oral report of results)
Student name:
Date of evaluation:
Evaluation by: Faculty member teaching Chemistry Seminar and/or Faculty Mentor
Faculty name:

Item	Criteria			Student Score
	Excellent	Adequate	Nominal	
Report	**[5 points]** A report having quality that might be submitted to a research journal. Includes background, data and methods, results, and discussion. Includes suggestion for further work.	**[3 points]** A good report but missing some aspect of an excellent report	**[1 point]** A report having minimal value	
Oral Presentation	**[5 points]** Clear, confident presentation. Audience questions are answered in a way to illustrate a complete knowledge of the topic.	**[3 points]** A good presentation but lacking clarity or confidence.	**[1 point]** An awkward, weak presentation but a presentation made nevertheless.	
Reflection	**[2 points]** A valuable reflection on the complete undergraduate chemistry experience.	**[1 point]** Some attempt at reflection but incomplete	**[0 points]** No reflection	
External presentation	**[2 points]** Presented results at an off-campus conference or meeting	**[1 point]** Presented a good poster at the Millikin undergraduate research symposium	**[0 points]** No presentation	
Total Points (14 max.)				

Millikin University
Department of Chemistry
Student Learning Evaluation

Evaluation of: Department Goal 2.
"Discover how to integrate and apply knowledge and skills both within the chemistry community and between chemistry and other disciplinary communities."
Item evaluated: The research proposal
Student name:
Date of evaluation:
Evaluation by: Faculty member teaching Introduction to Research
Faculty name:

Item	Criteria			Student Score
	Excellent	Adequate	Nominal	
Process	**[5 points]** A thorough explanation of previous work to a clear study question followed by analysis of previous work to synthesis into a coherent proposal.	**[3 points]** Shows some evidence of the process: explanation to conjecture to analysis to synthesis but incomplete.	**[1 point]** Restates some general ideas or issues but shows no evidence of analysis.	
Connection	**[3 points]** A good proposal has a history. This includes your personal experience, it has a real-world context, and it has a connection to previous work both at Millikin and in the literature.	**[2 points]** Shows you understand the history of the proposal by examining some of your own experiences in the past as they relate to the proposal but otherwise incomplete.	**[1 point]** Minimal connections made.	
Readings	**[4 points]** In-depth synthesis of thoughtfully selected aspects of readings related to the proposal. The readings are significant and appropriate at the college level. While you may use data and primary texts collected from the internet, the majority of readings are from library sources. Makes *clear* connection between what is learned from readings and the proposal.	**[2 points]** Goes into more detail explaining some specific ideas or issues from readings related to the topic. Makes general connections between what is learned from readings and the topic.	**[1 point]** You show some evidence of reading about the topic and are able to state some general ideas or issues from readings related to the topic. But there is no evidence of library research beyond the class textbook, secondary sources and the internet.	
Grammar	**[2 points]** No spelling or grammar errors.	**[1 point]** Few spelling and grammar errors.	**[0 points]** Many spelling and grammar errors, use of incomplete sentences, inadequate proof reading.	
Total Points (14 max.)				

Millikin University
Department of Chemistry
Student Learning Evaluation

Evaluation of: Department Goal 3.
"Develop the capacity to address real-world scenarios in which chemistry plays a role."
Item evaluated: Research (evaluation by faculty mentor using notebook)
Student name:
Date of evaluation:
Evaluation by: Faculty mentor
Faculty name:

Item	Criteria			Student Score
	Excellent	Adequate	Nominal	
Quantity	**[5 points]** You work consistently over the entire research period with clear evidence of significant weekly work. You consistently report to faculty mentor.	**[3 points]** You work consistently most of the time but miss from time to time.	**[1 point]** You try to cram the work into a short period.	
Quality	**[3 points]** You work efficiently with some measure of success. Your work is worthy of submission to an off-campus conference.	**[2 points]** You have some success but not at the level worthy of an off-campus conference.	**[1 point]** Work is not worth crowing about.	
Notebook	**[4 points]** Notebook is clearly written and contemporaneous.	**[2 points]** Notebook is contemporaneous but hard to follow.	**[1 point]** Your notebook is incomplete and a mess.	
Safety	**[2 points]** You consistently use safe practice and clean up your work area.	**[1 point]** You consistently use safe practice but leave a mess behind.	**[0 points]** You work in an unsafe manner.	
Total Points (14 Max.)				