

**Institutional Effectiveness**  
**2020-2021**

**Program:** Chemistry MS

**College and Department:** College of Arts & Sciences – Department of Chemistry

**Contact:** Jeff Boles

**Mission:** The mission of the graduate program in chemistry may be summarized as follows:

1. To provide an ongoing program of study that prepares graduates to successfully pursue scientific careers in industry or to continue their education in a doctoral program or professional school.
2. To provide students with opportunities to reinforce their background and expand their knowledge in areas integrated with their undergraduate coursework, with course offerings in the five major branches of chemistry.
3. To provide an ongoing, stimulating and intellectual atmosphere conducive to the learning process of both students and faculty through low student-to-faculty ratios.
4. To provide the facilities and professional mentorship enabling students to propose, conduct, evaluate, and report in a systemic way on original research and thereby add to the knowledge of humanity.
5. To provide opportunities for students to refine both oral and written communication skills.

The graduate curriculum is designed to acquaint students with the current ideas in the five major areas of chemistry (organic, inorganic, physical, analytical, and biochemistry). The thesis project affords the student practical experience in the methods used to obtain new knowledge and to develop the skills necessary to understand and relate this knowledge. Special topics courses allow individual professors to present specialized material in their area of expertise. The faculty maintains a wide variety of research programs, giving each student an opportunity to conduct, evaluate, and report on original research.

**Program Goals:**

- PG 1: Engage graduate students in cutting-edge research activities.
- PG 2: Decrease the traditional classroom teaching load of Graduate Faculty.
- PG 3: The Chemistry M.S. Program will maintain a satisfactory graduation rate.

**Student Learning Outcomes:**

Students will be able to:

- SLO 1: employ critical thinking skills to analyze a chemical problem, (Assessment Item 12 on M.S. Survey of Graduates, M.S. Survey of Faculty). Surveyed annually and compiled every 5 years.
- SLO 2: collect background information through the effective use of the scientific literature, (Assessment Item 13 on M.S. Survey of Graduates, M. S. Survey of Faculty). Surveyed annually and compiled every 5 years.

SLO 3: prepare a hypothesis, design and execute experiments to test the hypothesis, keeping complete experimental records, (Assessment Item 14 on M.S. Survey of Graduates, M. S. Survey of Faculty). Surveyed annually and compiled every 5 years.

SLO 4: apply appropriate statistical analysis to collected research data, (Assessment Item 15 on M.S. Survey of Graduates, M. S. Survey of Faculty). Surveyed every 5 years.

SLO 5: apply critical thinking skills to further refine the hypothesis based on experimental evidence (Assessment Item 12 on M.S. Survey of Graduates, M.S. Survey of Faculty). Surveyed annually and compiled every 5 years.

SLO 6: effectively communicate scientific knowledge and ideas through both oral and written communication skills.

A departmentally developed curriculum map can be found in Appendix 1 that shows the connections between courses and student learning outcomes.

### **Assessment Methods:**

#### *PG 1: Engage students in research*

1. SciFinder Scholar:

In order to assess our goal of increasing research productivity, SciFinder scholar is used to determine the number of peer-reviewed publications in each two-year period. The chemistry department annual report is generated each year and contains tabulated data such as external funding dollars raised and numbers of manuscripts published via SciFinder Scholar to show progress in research productivity, in part, as a funding outcome.

2. Chemistry Department Annual Report:

Information in the Chemistry Department Annual Report provides annual tabulation of the results of each program goal (Indirect, but containing information from Direct Measure Assessment). The Chemistry Department Annual Report is used to not only track such data, but is also disseminated to the faculty and discussed at faculty meetings and retreats, as are the other assessment tools. The graduate program is assessed by external peer-review every 5 years.

3. Delaware Study

Information in the Delaware Study will be utilized to determine and tabulate the total amount of external funds activated each year by the department. The University must file certain reports each year that indicate levels of funding support acquired from outside sources. The Delaware Report is thus very useful for acquiring this data.

#### *PG 2: Decrease teaching load*

1. Delaware Study

Information in the Delaware Study will be utilized to determine the actual teaching load assigned by the chair and the number of degrees awarded.

*PG 3: Maintain a satisfactory graduation rate.*

1. Graduation Rate

*SLOs 1-6:*

1. Seminar Evaluation Form

Both faculty and students attending student seminars fill out an evaluation form on the student speaker. This is helpful to both the student giving the seminar as well as the student grading the seminar. These are kept by the Seminar Program Coordinator, who also provides feedback to students, and to the M.S. Program Coordinator.

2. Chemistry M.S. Survey of Graduates

Specific items on this survey along with the students Graduate Advisory Committee will assess students' progress on each of the sub-outcomes. The survey of graduates will be administered every year beginning this year.

3. Chemistry M.S. Survey of Faculty

Specific items on this survey will assess students' progress on sub-outcomes. This survey is administered every five years.

4. Graduate Advisory Committees

Graduate Advisory Committees of the graduate students assess student progress at the time of the proposal presentation, the thesis seminar, and the oral defense of the written thesis.

A student with an advanced degree in chemistry must have sufficient critical thinking and problem-solving skills in order to succeed. Graduate Advisory Committees of the graduate students at the time of proposal presentations, literature seminar, thesis seminar, and oral defense of the written thesis will make evaluations of student progress. Progress and novel ideas for improvement are discussed within these committees, at faculty retreats and occasionally at faculty meetings. The results of the Chemistry M.S. Survey of Graduates and the Chemistry M.S. Survey of Faculty are also discussed at faculty meetings and retreats since they contain valuable information as a direct measure of assessment.

5. External Program Reviews

External program reviews (every 5 years) also contributes to improvements in the assessment tools utilized by the department. The results of these reviews are maintained in the Chemistry Chair's office.

**Results:**

*PG 1: Engage students in research*

SciFinder Scholar is used as the direct assessment tool. Two-Year cycle is defined, for example, as papers published during calendar year 2018 and 2019 and reported as 2018-2019, the last full assessment cycle for results for this metric.

Years Tabulated	# of Publications	Target (5% increase)
2001-2002	21	18
2003-2004	21	19
2005-2006	30	20
2007-2008	17	21
2009-2010	11	22
2011-2012	13	23
2013-2014	20	24
2015-2016	41	25
2017-2018	41	27
2018-2019	33	30
2020-2021	Available 12/21	Available 12/21
<b>2001-2021</b>	<b>265</b>	<b>205 (expected)</b>

The following table tabulates acquired funding by the department of Chemistry faculty since 2005. To provide an historical perspective: the four-year total research funding level in the department 1998-2002 was an average of \$121K per year. Our target is a research funding level that increases by 5% per year over the previous average. We have dramatically exceeded this goal (nearly tripled) as seen in the table below (Ref. Delaware Reports 2005-2006 through 2009-2010 and the Chemistry Annual Report).

Academic Year	Total New Awards	Target Level
2006-2007	\$1,037,689	\$126K
2007-2008	\$36,300	\$132K
2008-2009	\$283,013	\$139K
2009-2010	\$103,000	\$146K
2010-2011	\$122,253	\$153K
2011-2012	\$236,957	\$161K
2012-2013	\$94,309	\$169K
2013-2014	\$568,600	\$177K
2014-2015	\$725,046	\$185K
2015-2016	\$1,437,827	\$194K
2016-2017	\$545,294	\$203K
2018-2019	\$434,356	\$223K
2019-2020	\$443,651	\$234K
2020-2021	\$434,356	\$246K
<b>Total</b>	<b>\$7,572,776</b>	<b>\$2,821,000</b>

*PG 2: Decrease teaching load*

The average load of the research active faculty is 9.1 contact hours, however, the average load when all faculty are considered is 10.9 contact hours.

*PG 3: Maintain a satisfactory graduation rate.*

The table below illustrates August through May graduate rates. An average of 5 must be maintained.

Academic Year	Number of Graduates
2007-2008	4
2008-2009	6
2009-2010	6
2010-2011	6
2011-2012	5
2012-2013	6
2013-2014	4
2014-2015	6
2015-2016	7
2016-2017	10
2017-2018	5
2018-2019	4
2019-2020	11
2020-2021	4

*SLO 1: Employ critical thinking skills to analyze a chemical problem*

A rubric is used by the student's Graduate Advisory Committee to evaluate the oral thesis defense. One of the subjects evaluated is Critical Thinking. The percentages below each box show the percent of students whose evaluations fell into each category. (Only students for whom at least 2 faculty members provided an evaluation are included in this data.) Each student advisory committee is composed of three members. Each committee is also different, and faculty are likely to assess students differently. This must be taken into consideration since there is not enough data to normalize the evaluation scores. Data for 2019 and 2020 are shown. Data for 2021 is incomplete at this time.

Rubric for Faculty Evaluation of Thesis & Defense – Critical Thinking

Year	Excellent	Good	Fair	Poor
2019	13%	75%	13%	0%
2020	29%	71%	0%	0%

*SLO 2: Effective use of the scientific literature*

The rubric mentioned in SLO1 contains an evaluation of the students use of the scientific literature along with their ability to gather and organize sources that support or contribute to the research being undertaken. The percentages below each box show the percent of students whose evaluations fell into each category. (Only students for whom at least 2 faculty members provided an evaluation are included in this data.) Each student advisory committee is composed of three members. Each committee is also different, and faculty are likely to assess students differently. This must be taken into consideration since there is not enough data to normalize the evaluation scores. Data for 2019 and 2020 are shown. Data for 2021 is currently incomplete.

Rubric for Faculty Evaluation of Thesis & Defense – Information Seeking

Year	Excellent	Good	Fair	Poor
2019	63%	37%	0%	0%
2020	43%	57%	0%	0%

*SLO 3: SLO3: design and execute experiments*

The rubric mentioned in SLO1 contains an evaluation of the student’s participation in the thesis problem/question, including their ability to contribute to the hypotheses being tested. The percentages below each box show the percent of students whose evaluations fell into each category. (Only students for whom at least 2 faculty members provided an evaluation are included in this data.) Each student advisory committee is composed of three members. Each committee is also different, and faculty are likely to assess students differently. This must be taken into consideration since there is not enough data to normalize the evaluation scores. Data for 2019 and 2020 are shown. Data for 2021 is currently incomplete.

Rubric for Faculty Evaluation of Thesis & Defense – Thesis Problem

Year	Excellent	Good	Fair	Poor
2019	25%	62.5%	12.5%	0%
2020	57%	43%	0%	0%

*SLO 4: Apply appropriate statistical analysis*

The rubric mentioned in SLO1 contains an evaluation of the student’s contribution and analysis of collected information, including their ability to draw appropriate and inventive conclusions supported by the data presented in those sources. The percentages below each box show the percent of students whose evaluations fell into each category. (Only students for whom at least 2 faculty members provided an evaluation are included in this data.) Each student advisory committee is composed of three members. Each committee is also different, and faculty are likely to assess students differently. This must be taken into consideration since there is not enough data to normalize the evaluation scores. Data for 2019 and 2020 are shown. Data for 2021 is currently incomplete.

Rubric for Faculty Evaluation of Thesis & Defense – Analysis

Year	Excellent	Good	Fair	Poor
2019	37.5%	50%	12.5%	0%
2020	29%	43%	29%	0%

*SLO 5: Effectively documenting sources*

The rubric mentioned in SLO1 contains an evaluation of the student’s documentation of all utilized sources that were referred to in the process of carrying out the planned research. The percentages below each box show the percent of students whose evaluations fell into each category. (Only students for whom at least 2 faculty members provided an evaluation are included in this data.) Each student advisory committee is composed of three members. Each committee is also different, and faculty are likely to assess students differently. This must be taken into consideration since there is not enough data to normalize the evaluation scores. Data for 2019 and 2020 are shown. Data for 2021 is currently incomplete.

Year	Excellent	Good	Fair	Poor
2019	56%	44%	0%	0%
2020	56%	44%	0%	0%

*SLO 6: Effectively communicate scientific knowledge*

The rubric mentioned in SLO1 contains an evaluation of both the student’s written synthesis of their research, as well as their oral synthesis of their research (dissemination). The percentages below each box show the percent of students whose evaluations fell into each category. (Only students for whom at least 2 faculty members provided an evaluation are included in this data.) Each student advisory committee is composed of three members. Each committee is also different, and faculty are likely to assess students differently. This must be taken into consideration since there is not enough data to normalize the evaluation scores. Data for 2019 and 2020 are shown. Data for 2021 is currently incomplete.

**Rubric for Faculty Evaluation of Thesis & Defense – Written Synthesis**

Year	Excellent	Good	Fair	Poor
2019	37.5%	50%	12.5%	0%
2020	57%	14%	29%	0%

**Rubric for Faculty Evaluation of Thesis & Defense – Oral Synthesis**

Year	Excellent	Good	Fair	Poor
2019	62.5%	37.5%	0%	0%
2020	57%	43%	0%	0%

**Modifications for Improvement:**

SLO6: *Effectively communicate scientific knowledge*

Beginning in Spring 2021 the second literature seminar course, CHEM 6911, Literature Seminar, was reinvented by two research faculty. This course focuses on the use of Ted Talks, lectures, practice sessions and other similar learning tools to help students improved oral dissemination of data and interpretation of that data. The reinventing of CHEM 6911 will continue the progress we've seen since redesigning CHEM 6910.

**Appendices**

1. Chemistry MS Curriculum Mapping
2. Seminar Evaluation Form
3. MS Survey of Graduate
4. MS Survey of Faculty
5. Graduate Advisory Committee Thesis Assessment

**Appendix 1: Chemistry MS Curriculum Mapping**

<b>Chemistry, MS: Mapping of the Graduate Curriculum and Student Learning Objectives</b>						
	<b>SLO 1: Scientific Method</b>				<b>SLO 2: Communication</b>	
	<i>Critical Thinking</i>	<i>Literature</i>	<i>Hypothesis &amp; Experiment</i>	<i>Statistical Analysis</i>	<i>Oral</i>	<i>Written</i>
<b>CHEM 5000</b>					X	
<b>CHEM 5320</b>	X	X	X			
<b>CHEM 5410</b>						
<b>CHEM 5520</b>		X	X	X	X	X
<b>CHEM 6110</b>	X				X	X
<b>CHEM 6210</b>	X	X				X
<b>CHEM 6410</b>	X	X	X	X		X
<b>CHEM 6610</b>		X	X			X
<b>CHEM 6900</b>	X	X	X	X	X	X
<b>CHEM 6910</b>	X	X			X	X
<b>CHEM 6911</b>	X				X	
<b>CHEM 6990</b>	X	X	X	X		X

## Appendix 2: Seminar Evaluation Form

(Evaluator: **Please** make comments in the space to the right of each category as part of your grade. If you take this form with you to fill out at your leisure, please return it to *Kathy Rust* by the following Monday)

<b>Planning and preparation:</b> <i>Abstract clear, succinct, adequate detail in abstract and outline. Did the speaker adhere to the outline?, etc</i>	
	Award 1-20 points
<b>Presentation to audience:</b> <i>Voice level and clarity, enthusiasm, eye contact, absence of annoying actions, proper use of notes, entertaining style, correct grammar, timing, well-organized, professional demeanor</i>	
	Award 1-20 points
<b>Visual Aids: Relevance:</b> <i>effective use, quality, correct grammar, correct spelling, proper use of equipment, proper citations</i>	
	Award 1-20 points
<b>Subject matter:</b> <i>Knowledge about subject, presentation of scientific merit, use of literature, thorough understanding of material, etc</i>	
	Award 1-20 points
<b>Discussion:</b> <i>Interest aroused, ability to answer questions, adequate time allowed for questions</i>	
	Award 1-20 points
<b>General Comments:</b>	
<b>Total points:</b>	



Organization and clarity of M.S. degree requirements	1	2	3	45
Opportunities for professional and personal interactions with chemistry faculty <sup>1</sup>		2	3	45
Progress you made in learning to think critically and analyze chem. problems	1	2	3	45
Progress you made in learning to use the scientific literature	1	2	3	45
Progress you made in learning to keep organized research/laboratory records	1	2	3	45
Progress you made in learning to apply statistical analysis to data	1	2	3	45
Progress you made in learning to effectively communicate scientific info	1	2	3	45
Availability of your research advisor	1	2	3	45
Willingness of your research advisor to assist	1	2	3	45
Competence of your research advisor in his/her field	1	2	3	45
Assistance given by your advisory committee	1	2	3	45
Quality of <u>curricular</u> advising in M.S. chemistry	1	2	3	45
Quality of <u>career</u> advising in M.S. chemistry	1	2	3	45
Quality of classroom facilities	1	2	3	45
Quality of laboratory facilities	1	2	3	45
Quality of TTU library chemistry holdings	1	2	3	45
Quality of computer support	1	2	3	45
Availability of a stimulating intellectual atmosphere conducive to learning	1	2	3	45

Assistance given by departmental secretaries	1	2	3	45
Quality of my initial contact with the department	1	2	3	45
Opportunity for student participation in departmental decisions	1	2	3	45
Overall quality of the department	1	2	3	45
Overall satisfaction with M.S. degree program	1	2	3	45

**Please take time to share your thoughts and perceptions of the Chemistry Department in order to foster the improvement of its M.S. program and faculty.**

List or discuss the strengths of the department, faculty, and degree program.

List of discuss the weakness of the department, faculty, and degree program.

Any suggestions you may have to improve the department, its faculty, and programs would be appreciated.

## Appendix 4: MS Survey of Faculty

### Chemistry M. S. Survey of Faculty

Please rate your satisfaction or estimate the quality of the following items. Your responses will be kept anonymous.

If you rate the program fair or poor on any of the items below, please use the text boxes at the end of the survey to elaborate on your rating.

	<u>Poor</u>	<u>Fair</u>	<u>Good</u>	<u>Excellent</u>	
Not Applicable					Or
Perceived quality of instruction in graduate courses:					
Organic Chemistry	1	2	3	45	
Analytical Chemistry	1	2	3	45	
Inorganic Chemistry	1	2	3	45	
Physical Chemistry	1	2	3	45	
Biochemistry	1	2	3	45	
Organization and clarity of M.S. degree requirements	1	2	3	45	
Progress students make in learning to effectively use the scientific method	1	2	3	45	
Progress students make in learning to effectively communicate scientific info	1	2	3	45	
Progress students make in learning to think critically & analyze chem. problems	1	2	3	45	
Progress students make in learning to effectively use the scientific literature	1	2	3	45	
Progress students make in learning to keep organized research/lab records	1	2	3	45	
Progress students make in learning to apply statistical analysis to data	1	2	3	45	

Quality of recruitment of M.S. students	1	2	3	45
Quality of <u>curricular</u> advising of M.S. chemistry students	1	2	3	45
Quality of <u>career</u> advising of M.S. chemistry students	1	2	3	45
Quality of <u>research</u> advising of M.S. chemistry students	1	2	3	45
Intellectual quality of entering students	1	2	3	45
Academic preparedness of entering students	1	2	3	45
Quality of efforts to prepare TA's for effective lab teaching	1	2	3	45
Appropriateness of number of T.A. stipends afforded to the program	1	2	3	45
Appropriateness of dollar amount of T.A. stipends	1	2	3	45
Level of operating budget afforded to the department	1	2	3	45
Quality of classroom facilities	1	2	3	45
Quality of laboratory facilities	1	2	3	45
Quality of TTU library chemistry holdings	1	2	3	45
Quality of computer support	1	2	3	45
Quality of instrumentation for graduate research	1	2	3	45
Quality of instrument maintenance for graduate research	1	2	3	45
Quality of research activity of the faculty	1	2	3	45

Availability of a stimulating intellectual atmosphere conducive to learning	1	2	3	45
Availability of faculty development opportunities, sabbaticals, etc.	1	2	3	45
Assistance given by departmental secretaries	1	2	3	45
Opportunity for faculty participation in program decisions	1	2	3	45
Overall satisfaction with M.S. degree program	1	2	3	45

What are the major concerns that you have about the M.S. program that you wish to see addressed in this program review?

List or discuss the strengths of the department and faculty as they pertain to the M.S. degree program.

List or discuss the weaknesses of the department and faculty as they pertain to the M.S. degree program.

Any suggestions you may have to improve the M.S. program.

**Appendix 5: Graduate Advisory Committee Thesis Assessment**

**Thesis/Research Defense Assessment**

**Student Name** \_\_\_\_\_ **Points** \_\_\_\_\_

<b>* Point Value</b>	<b>Thesis/ Problem/ Question</b>	<b>Information Seeking/Selecting and Evaluating</b>	<b>Analysis</b>	<b>Written Synthesis</b>	<b>Documentation</b>	<b>Oral Synthesis</b>	<b>Critical Thinking</b>
<b>4</b>	Student contributed to thoughtful, creative hypotheses that engaged them in challenging or provocative research. The research breaks new ground or contributes to knowledge in a focused, specific area.	Student gathered information from a variety of quality electronic and print sources, including appropriate databases. Sources are relevant, balanced and include critical information relating to the thesis or problem. Primary sources were included.	Student carefully analyzed the information collected and drew appropriate and inventive conclusions supported by data.	Student developed appropriate structure for communicating data and conclusions, incorporating a variety of quality sources. Information is logically and creatively organized with smooth transitions. Little faculty assistance was required (mostly general editing).	Student documented all sources. Sources were properly cited in both written thesis and presentation slides. Documentation is error-free.	Student effectively and creatively used appropriate communication tools to convey their conclusions and demonstrated thorough, effective research techniques. Work displays creativity and originality.	Student demonstrated critical thinking by asking appropriate questions, considering legitimacy of sources and evaluation of data
<b>3</b>	Student contributed to focused hypotheses involving them in challenging research.	Student gathered information from a variety of relevant sources--print and electronic. Some were not very relevant.	Student conclusions shows good effort was made in analyzing the data collected	Student logically organized the methods employed and results generated. Average faculty assistance was required.	Student documented sources are sufficient in general. Few errors noted.	Student effectively communicated the results of research to the audience.	Student demonstrated critical thinking by asking appropriate questions and considering legitimacy of sources.
<b>2</b>	Student contributed little to the hypothesis. Contributions by student lend to readily available answers.	Student gathered information from a limited range of sources and displayed minimal effort in selecting quality resources	Student conclusions could be supported by stronger evidence. Level of analysis could have been deeper.	Student could have put greater effort into organizing the thesis. Much faculty-generated assistance was required.	Student needs to use greater care in documenting sources. Documentation was poor or absent.	Student needs to work on communicating more effectively.	Student needed to ask more critical questions than normal in the process of working through the project.
<b>1</b>	Student relied solely on faculty-generated hypotheses or developed a hypothesis requiring little creative thought.	Student gathered information that lacked relevance, quality, depth and balance.	Student conclusions simply involved restating information. Conclusions were not supported by evidence.	Student work was not logically or effectively structured and required extensive faculty-generated assistance.	Student(s) clearly plagiarized material.	Student showed little evidence of thoughtful research. Presentation does not effectively communicate research findings.	Student did not apply critical thinking to the topic or the sources used in the research.
<b>Comments</b>							

\* The maximum number of possible points is 28. Indicate which box best reflects effort/progress in each column with a check and total points using point value in column 1.

**Graduate Advisory Committee Members** \_\_\_\_\_