Institutional Effectiveness

2021-2022

Program: Chemistry BS

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

Contact: Jeff Boles

Mission: The primary mission of the Department of Chemistry is the chemical education of students at Tennessee Technological University. The goals of the department are based on state and national needs and are consistent with the philosophy of the American Chemical Society which approves the curriculum for students wishing to become professional chemists. The offerings in chemistry are designed to develop an understanding of the relation of chemistry with daily life for all students and to prepare students for careers in chemistry and in related scientific, medical, and technological fields. The goal is also to provide both undergraduate and graduate students the facilities, opportunity, and inducement to conduct, evaluate, and report on original research under the supervision of a faculty mentor and thereby add to the knowledge of mankind while participating in team-based approaches to learning that are likely to be encountered in a graduate's career.

Undergraduate Program: BS Chemistry Program Description

Concentrations (abbreviations):
CHMA – ACS certified Chemistry Major
CHMP – Pure Chemistry Major
CHMN – Applied Chemistry Major
CHMN – Biochemistry Major

Catalog Program Listings (revised in 2008 to provide enhanced student learning outcomes)

CHMA: The A.C.S. concentration is intended to prepare students for graduate school or to pursue chemistry as a profession in industry.

CHMP: The CHMA concentration was renamed CHMP in 2008 (Pure Chemistry), in part due to the changes made by the American Chemical Society for certification of degrees since ACS dissolved each of its degree programs and asked Universities to develop their own programs in line with program strength, regional needs and student need. The CHMP concentration exceeds the minimum requirements for ACS certified degrees.

CHMN: The Applied Chemistry concentration was originally (2005) intended to serve pre-professional students and those who do not intend to pursue graduate study in chemistry. Since the American Chemical Society dissolved all of its degree programs and asked Universities to develop degree programs that addressed student need and took advantage of program strength, we chose to act on this request immediately. TTU Chemistry was one of the first departments to create new curricula meeting certification requirements in the country. With the involvement of TTU Chemistry Alumni (and some Chemistry Advisory Board Members), we developed the following Options within Applied Chemistry, each of which is certifiable by the American Chemical Society if certain required course substitutions are made in the student's program of study.

a. Business Chemistry – This option is intended for those who are more interested in the business side of the chemical industry or in a management career in a technical industry. The non-chemistry component of this option includes most, if not all, of the coursework necessary to enter the +1 MBA program offered by the TTU College of Business.

b. Environmental Chemistry – Chemistry plays a central role in all environmental issues. No student can be considered prepared to contribute to this field without a solid background in chemistry. This option incorporates a significant amount of supporting coursework in contributing sciences, such as biology, agriculture, and geology.

c. Forensic Chemistry – Forensic science is an interdisciplinary field incorporating aspects of chemistry, biology, and physics. While it is certainly an area of current popular interest, it has long been a career pathway for chemistry graduates, whose curriculum fits these demands particularly well. This option combines the essential elements of chemistry with supporting coursework in biology and criminal justice.

d. Health Sciences Chemistry - This option provides a four-year content degree in chemistry for students who have pursued non-degree curricula in pre-medicine, pre-dentistry, pre-pharmacy, pre-optometry and other related pre-health programs. Supporting coursework in biology is chosen from those courses required or encouraged by professional schools.

e. Industrial Chemistry – This option is intended for students who wish to pursue a technical career in a chemistry-related industry. Many companies seek employees with a chemical background but do not need the rigorous training found in the ACS Chemistry concentration. An integral part of this program is a minimum of one year of cooperative employment experience.

f. Chemistry – This option maintains the flexibility of the current program, allowing adaptation to new areas of interest as they develop.

CHMB: The Biochemistry concentration is intended to serve those who wish to pursue graduate work at the chemistry-biology interface.

Program Goal:

PG 1: Increase external funding by 5% per year to improve quality of research and student involvement in research**.**

Student Learning Outcomes:

SLO 1: Demonstrate mastery of factual knowledge and high level of critical thinking**.**

a. Senior chemistry majors in all three concentrations will be able to demonstrate a mastery of factual knowledge comprehensively across the five principal areas of chemistry (organic, inorganic, physical, analytical and biochemistry), and be able to analyze and solve problems, understand relationships, and interpret scientific facts and data. cohort = CHMP, CHMB, CHMN (CHMA is now named CHMP).

b. Senior chemistry majors in all three concentrations will be able to demonstrate a high level of critical thinking and reasoning ability within the context of the chemical discipline. cohort = CHMP, CHMB, CHMN

c. Senior chemistry majors in the biochemistry concentration will be able to demonstrate a mastery of modern factual knowledge in Biochemistry**.** cohort =CHMB

SLO 2: Successful entrance into high quality graduate schools, admission to professional schools, and securing quality careers in the chemical sciences.

a. Chemistry BS Graduates will be successful in gaining entrance into high quality graduate schools in chemistry, admission to professional schools**,** and securing quality careers in the chemical sciences. cohort =CHMP, CHMB, CHMN (all cohorts).

SLO 3: Demonstrate ability to integrate chemical knowledge in undergraduate research projects as well as work well in team-based research**.**

a. Senior chemistry majors will be able to demonstrate ability to integrate chemical knowledge in the successful conduct of undergraduate research projects as well as work well in team-based research by graduation. cohort =CHMP, CHMB, CHMN (all cohorts).

SLO 4: Demonstrate a thorough knowledge of general chemistry.

a. Students completing the main sequence general chemistry CHEM1110/1120 will be able to demonstrate a thorough knowledge of general chemistry as evidenced by exceeding the average score on exams that are professionally equivalent to the National ACS General Chemistry Exam**.**

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: Increase external funding

1. Annual Report

The annual report is largely a data repository but also includes content related to the evolving history of the department. Matriculation to graduate and professional schools as well as the number of students conducting research during the academic year and/or presenting research at regional and national scientific meetings are collected and tabulated in the annual report.

2. 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**.**

SLO 1: Demonstrate knowledge and critical thinking

1. ETS Chemistry Field Exam

Student Performance on the national ETS Chemistry Field Exam in the four branches of chemistry (referred to as subscores 1 through 4) for Outcome 1. Student performance, Assessment Indicator #2 (Critical Thinking and Reasoning Ability) for Outcome 2. Senior performance on the ETS Chemistry Field Exam -Assessment indicator #1 (Biochemistry knowledge assessment) for Learning Outcome 3.

- This mastery level by TTU students on the ETS Field Exam**,** which should exceed the national average for CHMA majors as demonstrated on the ETS Chemistry Field Exam, is discussed at faculty meetings (cohort = CHMP, CHMB, CHMN).
- This mastery level by TTU students for critical thinking and reasoning ability on the ETS Field Exam that should meet or exceed the national average for chemistry majors as demonstrated on the ETS Chemistry Field Exam is discussed with faculty at faculty meetings (cohort = CHMP, CHMB, CHMN)
- This mastery level by TTU CHMB students on the ETS Field Exam, which should exceed the national average as demonstrated on the Biochemistry knowledge assessment of the ETS Chemistry Field Exam, is taken into consideration during faculty planning for our one-year intensive biochemistry course (cohort = CHMB)

SLO 2: Successful graduates

1. Annual Report

The annual report is largely a data repository but also includes content related to the evolving history of the department. Matriculation to graduate and professional schools as well as the number of students conducting research during the academic year and/or presenting research at regional and national scientific meetings are collected and tabulated in the annual report.

2. Senior Surveys

Graduating Senior Surveys provides a variety of data about the program and is discussed at faculty meetings and faculty retreats in order that the faculty have the opportunity to assess/reflect on student outcome goals. cohort =CHMP, CHMB, CHMN

SLO 3: Integrate chemical knowledge and team work

1. Annual Report

The annual report is largely a data repository but also includes content related to the evolving history of the department. Matriculation to graduate and professional schools as well as the number of students conducting research during the academic year and/or presenting research at regional and national scientific meetings are collected and tabulated in the annual report.

2. ACS National Meetings Program

   Each year, the American Chemical Society publishes a program that includes the names of faculty and students presenting research along with their titles and abstracts.

SLO 4: Knowledge of general chemistry

1. General Chemistry Exam

   The National ACS General Chemistry exam**,** purchased from the ACS-CPT was given to all of our students in CHEM 1120 each Spring semester for many years. This exam covers material from both CHEM 1110 and 1120. It has been useful since it contains the scores of hundreds of students from a large number of Universities nationwide. We created an in-house professionally equivalent exam in 2017 and track progress with that test. Results are shared with faculty and discussed at faculty meetings and retreats.

2. *CHEM 1110 & 1120 Final Exams*

   Chemistry 1110 and 1120 final exams are written by our faculty as professionally equivalent exams as prepared by the ACS. We utilize that exam for 5 years as an assessment tool.

3. *CHEM 1110 & 1120 D/F/W rates*

   The percentage of students that score a grade of D or F along with those that withdraw from the course, are utilized as an additional assessment metric.

Results:

PG 1: Increase external funding

We track acquired funding by the department of Chemistry faculty and have been doing so since 2005. Our target is a research funding level that increases by 5% per year above the $121K base year. We typically exceed this goal as seen in the table below.

External Funding Awarded to Departmental Faculty

Academic Year	Total New Awards (or Activations)	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
2017-2018	$950,133	$213K
2018-2019	$434,356	$223K

2019-2020	$443,651	$234K
2020-2021	$434,356	$246K
Total Last 15 years	$ 7,572,776	$2,821,000

SLO 1: Demonstrate knowledge and critical thinking

The results of ETS Chemistry exams are shared with the respective areas and discussed at faculty meetings or retreats.

Mean scores for ETS Chemistry Exam by Sub-test

	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020	Spring 2021
# of students	*11*	*2*	*21*	*5*	*21*	*1*	*14*	*1*	*17*
1. Physical Chemistry	45	25	42	41	53	62	45	62	46
2. Organic Chemistry	45	33	48	46	55	47	47	47	45
3. Inorganic Chemistry	50	31	46	44	57	61	46	61	45
4. Analytical Chemistry	46	35	45	44	57	56	44	56	44
National Score	49	49	49	50	50	50	50	50	50
TOTAL	146	129	146	143	157	158	146	158	145

Mean scores for ETS Chemistry Exam Critical Thinking and Reasoning

	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020	Spring 2021
# of students	*18*	-	*22*	*5*	*21*	-	*14*	-	*17*
Critical Thinking and Reasoning	41	-	38	35	52	-	40	-	39

While the ETS Chemistry Biochemistry Assessment indicator does not reflect an actual Biochemistry exam, it does incorporate questions which allow assessment of biochemical knowledge, thus, we track these scores.

Mean scores for ETS Chemistry Exam Biochemistry Aspects

	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020	Spring 2021
# of students	*18*	-	*22*	*5*	*21*	-	*14*	-	*17*
Biochemistry Aspects	46	-	53	48	57	-	55	-	50

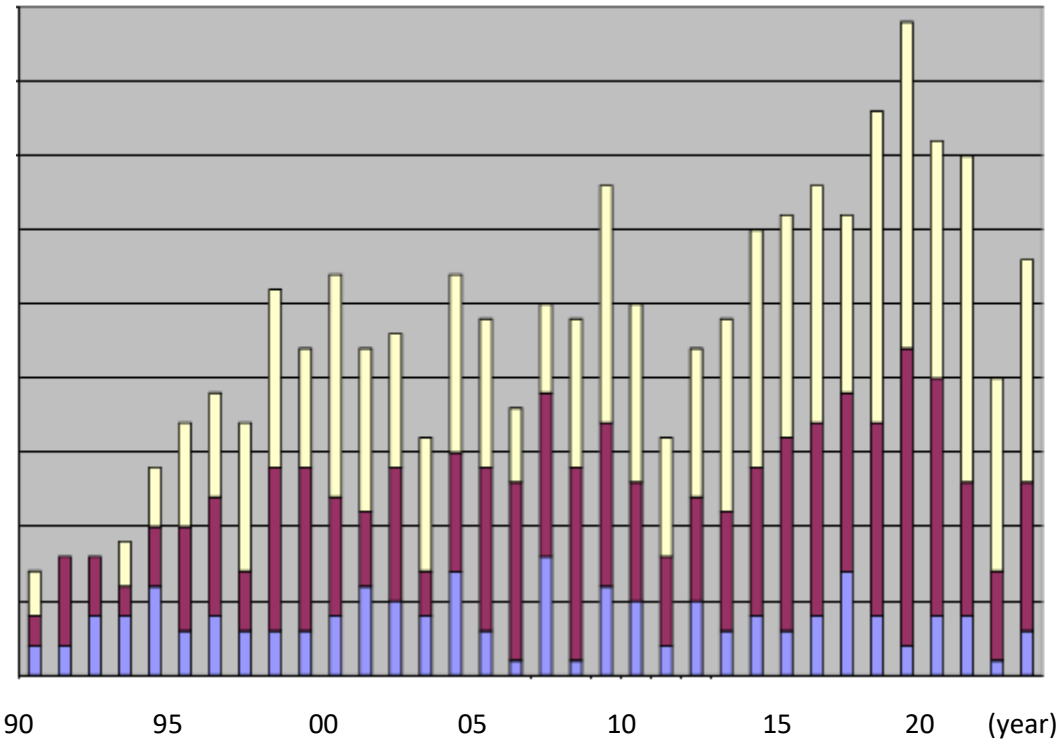
The ACS Biochemistry exam has been much more reliable as this is an actual Biochemistry exam written by the American Chemical Society. However, only students taking the full year Biochemistry sequence take this exam. The ACS does not provide an exam that only covers the fundamentals of biochemistry.

Percentiles for ETS Biochemistry Aspects and ACS Biochemistry exam

	2016	2017	2018	2019	2020	2021
ETS Biochemistry Aspects (Percentile)	63	52	48	54	N/A	50
ACS Biochemistry Exam (Percentile)	63	60	64	65	65	67

SLO 2: Successful graduates

The number of graduates in our BS program are tracked and tabulated each year. This also serves as a good history of our program going back three decades. Each horizontal bar represents 5 graduates.



Students matriculated to Tennessee Eastman Chemical Company (Kingsport), TVA (Spring City, Tn), Aegis (Nashville, Tn.), Tennessee Bureau of Investigation (Nashville, Tn), other industrial sites and several graduate and professional schools (medical, dental, etc.).

SLO 3: Integrate chemical knowledge and team work

Data from the Chemistry Department Annual Report and ACS National Meeting Programs are used to tabulate the number of active students in research and the number of students presenting their research at national ACS meetings. TTU chemistry sends one of the largest groups of undergraduate students to the national ACS meeting to present the results of their research. The following table tabulates the participation of undergraduates at the National meeting of the ACS.

Academic Year	Students Active in Undergrad Research	Research Presented at the National ACS Meeting
2020-2021	71	7 (Meeting Held Online – COVID)
2019-2020	74	- Meeting Cancelled - COVID
2018-2019	71	22 (Orlando, FL)
2017-2018	74	19 (New Orleans, LA)
2016-2017	72	15 (San Francisco, CA)
2015-2016	77	26 (San Diego, CA)
2014-2015	77	26 (Denver, CO)
2013-2014	72	22 (Dallas, TX)

SLO 4: Knowledge of general chemistry

Beginning Fall 2017, we initiated an exam professionally equivalent to the ACS exam. We give this exam each semester. The average score on the ACS exam is typically close to 50%. Our goal has been to maintain a 50 percentile score.

TTU General Chemistry Assessment

Year	Average Score
2017	51
2018	54
2019	53
2020	Pause (Covid)
2021	48

DFW Rates in CHEM 1120 (second semester of two-semester sequence)

CHEM 1120	DFW Percent
Spring 2018	35.5%
Spring 2019	36.2%
Spring 2020	21.1%
Spring 2021	42.5%

Modifications for Improvement:

Specific Actions :

SLO 4: Knowledge of general chemistry

A one-hour recitation has been added in place of a traditional pre-lab lecture. During 2020-2021, students were mostly online watching livestreamed or recorded lectures. As a result, DFW rates

increased sharply. This may be the reason the average on the final exam was lower, as well. Students are now attending class unless ill or in quarantine. This is a significant modification that essentially provides an attendance-required help session each week.

Appendices

1. Curriculum Map
2. Graduating Senior Survey

Appendix 1: Curriculum Map

Chemistry BS

Course	Title	Student Outcomes				
		SLO1		SLO2	SLO3	SLO4
		Factual knowledge	Critical thinking	Research	Teamwork	Knowledge of Gen Chem
1110	General Chemistry I	X	X		X	X
1120	General Chemistry II	X	X		X	X
1500	1st-Yr Interactions/Advisement	X	X	X	X	
2010	Intro to Inorganic Chemistry	X	X			
2910	Undergraduate Research Methods	X	X			
2920	Undergraduate Research Methods II	X	X	X	X	
3010	Organic Chemistry I	X	X			
3020	Organic Chemistry II	X	X			
3410	Quantitative Analysis	X	X		X	
3420	Analytical Applications	X	X		X	
3500	Elements of Physical Chemistry	X	X			
3510	Physical Chemistry I	X	X		X	
3520	Physical Chemistry II	X	X		X	
4110	Inorganic Chemistry	X	X			
4150	Inorganic Chemistry Lab	X	X		X	
4210	Chemistry of Polymers	X	X			
4310	Nuclear Chem & Radiochemistry	X	X		X	

4320	Spectro Ident-Organic Compounds	X	X	X	X	
4410	Forensic Chemistry	X	X	X	X	
4520	Instrumental Analysis	X	X	X	X	
4610	General Biochemistry I	X	X			
4620	General Biochemistry II	X	X			
4650	General Biochemistry Lab	X	X		X	
4710	Environmental Chemistry	X	X			
4720	Advanced Environmental Chemistry	X	X			
4910	Chemistry Seminar	X	X	X	X	
4970	Special Topics	X	X	X	X	
4991	Undergraduate Research	X	X	X	X	
4992	Undergraduate Research	X	X	X	X	
4993	Undergraduate Research	X	X	X	X	

Appendix 2: Graduating Senior Survey

TENNESSEE TECHNOLOGICAL UNIVERSITY

DEPARTMENT OF CHEMISTRY

GRADUATING SENIOR SURVEY

Major:_____ Emphasis:_____ Advisor: _____

Years at TTU:_____ Years in the Department:_____ Original major at TTU: _____

Please rate your satisfaction or estimate the quality of the following items.

	Poor	Fair	Good	Excellent	Not Applicable
Quality of courses in preparing me for employment/graduate school	1	2	3	4	5
Quality of instruction in: General Chemistry	1	2	3	4	5
Organic Chemistry	1	2	3	4	5
Analytical Chemistry	1	2	3	4	5
Inorganic Chemistry	1	2	3	4	5
Physical Chemistry	1	2	3	4	5
Biochemistry	1	2	3	4	5
Fairness in grading my courses	1	2	3	4	5
Availability of required courses	1	2	3	4	5
Opportunity for formal student evaluation of instruction in chemistry courses	1	2	3	4	5
Quality of general education courses	1	2	3	4	5
Organization and clarity of curriculum requirements	1	2	3	4	5
Opportunities for professional and personal interactions with chemistry faculty	1	2	3	4	5
Opportunities for students to participate in faculty research	1	2	3	4	5
Availability of advisor	1	2	3	4	5
Willingness of advisor to assist	1	2	3	4	5
Quality of curricular advising in chemistry	1	2	3	4	5
Quality of career advising in chemistry	1	2	3	4	5
Quality of classroom facilities	1	2	3	4	5
Quality of laboratory facilities	1	2	3	4	5
Quality of TTU library chemistry holdings	1	2	3	4	5
Quality of computer support	1	2	3	4	5
Availability of professional activities or clubs in the department	1	2	3	4	5
Assistance given be departmental secretary	1	2	3	4	5
Assistance given by stockroom manager	1	2	3	4	5
Quality of my initial contact with the department	1	2	3	4	5
Opportunity for student participation in departmental decisions	1	2	3	4	5
Overall quality of the department	1	2	3	4	5
Overall satisfaction with degree program	1	2	3	4	5

Please take time to share your thoughts and perceptions of the Department in order to foster the improvement of its 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