

Institutional Effectiveness 2023-2024

Program: Chemistry BS

College and Department: 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.

Attach Curriculum Map (Educational Programs Only):

BS Chemistry Program Concentrations:

- **CHMP** – Pure Chemistry Major
- **CHMN** – Applied Chemistry Major
- **CHMB** – Biochemistry Major
- **ACHB** - Business Chemistry Major
- **ACHF** - Forensic Chemistry Major
- **AECH** - Environmental Chemistry Major
- **AHSC** - Health Science Chemistry Major
- **AICH** - Industrial Chemistry Major
- **ACCH** - Custom Chemistry Major

CHMP: Pure Chemistry - The CHMP concentration exceeds the minimum requirements for ACS certified degrees.

CHMN: Applied Chemistry - The CHMN concentration is being phased out. It originally contained several options which have been converted to individual concentrations.

CHMB: Biochemistry - The Biochemistry concentration is intended to serve those who wish to pursue graduate work at the chemistry-biology interface, seek employment in the biotech industry or pursue medical, dental, pharmacy or optometry school.

ACHB: Business Chemistry – This option is intended for those who are more interested in the business side of 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.

ACHF: 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.

AECH: 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.

AHSC: Health Sciences Chemistry - This option provides a four-year content degree in chemistry for students pursuing entrance into medicine, dentistry, pharmacy, optometry and other related graduate health programs. Supporting coursework in biology is chosen from those courses required or encouraged by professional schools.

AICH 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 one-year cooperative employment experience.

ACCH: Custom Chemistry – This option provides the ability to design a curriculum based on a student-centered goal, such as geochemistry.

Attached Files: Appendix 1

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

Define Outcome:

1. Senior chemistry majors in all nine 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: cohort = All concentrations).
2. Senior chemistry majors in all three concentrations will be able to demonstrate a high level of critical thinking. cohort = All concentrations
3. Senior chemistry majors in the biochemistry concentration will be able to demonstrate a mastery of modern factual knowledge in Biochemistry. cohort =CHMB

Assessment Methods:

ETS Field Exam: Seniors are required to take the **ETS Chemistry Field Exam** before they graduate. This tool shows how they perform in each area of chemistry (Analytical, Physical, Organic and Inorganic). Student Performance on the national **ETS Chemistry Field Exam** in the four branches of chemistry (referred to as sub scores 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.

Criteria for Success (Thresholds for Assessment Methods):

1. The faculty of the Department of Chemistry discuss/decide the expected performance in each area of this exam. This **mastery level** on the **ETS Field Exam**, should exceed the national average for all concentrations as demonstrated on the ETS Chemistry Field Exam.
2. This **mastery level for critical thinking** and reasoning ability on the ETS Field Exam should meet or exceed the national average for chemistry majors as demonstrated on the ETS Chemistry Field Exam.
3. This **mastery level** by TTU CHMB students on the ETS Field Exam should meet or **exceed the national average as demonstrated on the Biochemistry knowledge assessment** of the ETS Chemistry Field Exam (cohort = CHMB).

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning,1.B General Education Curriculum,2.A Technology Infused Programs

Results and Analysis:

Results

Physical Chemistry

Term	2021	2022	2023	2024	2025	2026
	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile
Spring	46/49.4%	41/50.6%	44/51.5%	43/29%		
Fall	50/50%	40/63%	46/57%			

Organic Chemistry

Term	2021	2022	2023	2024	2025	2026
	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile
Spring	45/47%	40/48%	44/46%	43/48%		
Fall	53/50%	46/55%	45/71%			

Inorganic Chemistry

Term	2021	2022	2023	2024	2025	2026
	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile
Spring	45/53%	43/40%	49/44.5%	45/57%		
Fall	44/67%	43/55.2%	43/29%			

Analytical Chemistry

Term	2021	2022	2023	2024	2025	2026
	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile	Mean/%ile
Spring	44/47%	43/47.6%	44/48%	45/52%		
Fall	44/25%	42/53.9%	44/57%			

Biochemistry

Term	2021	2022	2023	2024	2025	2026
	TTU/National Mean	TTU/National Mean	TTU/National Mean	TTU/National Mean	TTU/National Mean	
Spring	50/49	51/n.a.	51/49.5	43/49.3		
Fall	57/54	47/n.a.	51/49.5			

Critical Thinking

Term	2021	2022	2023	2024	2025	2026
	TTU/National Mean	TTU/National Mean	TTU/National Mean	TTU/National Mean	TTU/National Mean	
Spring	39/39	35/n.a.	40/41	38/40.7		
Fall	43/41	35/n.a.	38/41			

Seniors take the ETS exam during their last semester (Fall or Spring)

As can be seen in each area above, senior chemistry majors are scoring very close to the national average or 50 percentile in most areas. In some instances they are scoring slightly above or slightly below.

Biochemistry faculty knowledge is consistently at or above the national average until Spring 2024 when our students dropped below the national mean. Critical-Thinking scores are slightly below the national mean.

Use of Results to Improve Outcomes:

Chemistry faculty were made aware each area would be assessed by the ETS exam and were encouraged to increase critical-thinking components in each area, as well.

SLO 2: Demonstrate chemical knowledge in faculty-directed undergraduate research.**Define Outcome:**

1. Chemistry majors will be able to demonstrate ability to **integrate chemical knowledge** in the successful conduct of **undergraduate research projects** by graduation. cohort = all concentrations.
2. Students in all chemistry concentrations will have opportunity to learn to work as part of a research team.

Each Fall semester, the department holds a research mini-symposia and all undergraduates are invited to attend. The purpose of the symposia is to make sure all undergraduates that seek this opportunity (research) identify areas of research interest ongoing in faculty research laboratories.

Assessment Methods:

Assessment of this goal is made by tabulating the number of students each year that undertake undergraduate research along with those that disseminate their research in the form of a presentation at a local, regional, or national conference. The Faculty meet and discuss what signifies success and has decided that 50% of our students, at a minimum, should be involved in undergraduate research. The **annual report** is largely a data repository but also includes content related to the evolving history of the department. 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. The American Chemical Society and American Society of Biochemistry and Molecular Biology publishes abstracts of student and faculty research presentations as a second direct measure of assessment.

Criteria for Success (Thresholds for Assessment Methods):

The faculty of the chemistry department meet and decide the criteria for success. At least 50% of the chemistry majors will conduct research as part of a faculty research lab team. At least 25% will present their research at a local, regional or national scientific meeting.

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning,1.D High Impact Practices,2.A Technology Infused Programs

Results and Analysis:

Academic Year	# Chem Majors	# Research Active	% Research Active	% Presenting Res.
2020-2021	165	55	33.3%	20%
2021-2022	144	53	36.8%	65%
2022-2023	139	51	40%	82%
2023-2024	128	52	40.6%	75%
2024-2025				
2025-2026				

The number of students engaged in undergraduate research has remained stable for the last four years, however, the percentage of those students presenting their research at local, regional or national meetings has increased. This is best explained by the impact of the COVID pandemic. In 2020-2021, very few professional meetings were held, and those were mostly online (virtual meetings). The number of meetings held increased the following year (2021-2022) and by the fall of 2022, essentially all meetings became available to students.

Use of Results to Improve Outcomes:

The department of chemistry holds a research mini-symposia each Fall semester which encourages undergraduates to become active in research. Rather than only email students to invite them to the research mini-symposia each fall semester, an activity used to encourage undergraduates to become active in research, hallway monitors are also now used to disseminate activities that encourage research activity.

SLO 3: Demonstrate knowledge of general chemistry for STEM majors.

Define Outcome:

- 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**. Cohort: All students enrolled in CHEM 1110/1120.

Assessment Methods:

- **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.

Criteria for Success (Thresholds for Assessment Methods):

Faculty in the department of chemistry meet and decide the criteria for success. Increased class averages on the comprehensive final exam coupled with a decrease in DFW rates as a result of modifications for continuing improvement signify success. Any level of increase is identified as acceptable.

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning,1.B General Education Curriculum,2.A Technology Infused Programs

Results and Analysis:

	Spring 2022	Spring 2023	Spring 2024	Spring 2025	Spring 2026
Exam Score	54.32	51.85	50.71		
DFW Rate	39.0	43.2	31.9		

A decrease in the average score on the CHEM 1120 final exam was noted compared to Spring 2022, however, these scores are near the median for national assessment exams (50 percentile). A decrease in DFW rates is noted for the 2023-2024 cohort.

Use of Results to Improve Outcomes:

We piloted having TAs hold office hours in our Study Hall for lab questions in the Spring. We will be expanding this and investing in trying to encourage students to make use of the existing resources, specifically Study Hall, for both lecture and lab. In Spring 2025 we will be conducting an evaluation of available course materials for implementation in Fall 2025.

Summative Evaluation:

The students worked on worksheets in groups in the classroom setting as an active-learning exercise. Instructors walked around the room giving assistance to the students as needed. This did not result in appreciable changes in student success. In the spring we piloted general chemistry teaching assistants holding office hours in our Study Hall during the Spring Semester (12:00-5:00 Mon - Thur). We think this may help improve student success on general chemistry exams.

Assessment Plan Changes:

We will be expanding the use of teaching assistants and encourage students to make use of the existing resources, specifically Study Hall, for both lecture and lab. In Spring 2025 we will be conducting an evaluation of new (available) course materials for implementation in Fall 2025.

List of Appendices:

Appendix 1: Chemistry BS Curriculum Map

Appendix 1: Chemistry BS 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		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	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	