

Chemistry BS: 2018-2019

Definition of Unit

Providing Department:

Chemistry BS

Department/Unit Contact:

Jeff Boles

Mission/Vision Statement:

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.

Program Description

Providing Department:

Chemistry BS

Department/Unit Contact:

Jeff Boles

Mission/Vision Statement:

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 students 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.

Learning Goal 1: Mastery of Factual Knowledge and Critical Thinking Skills

Define Goal:

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

Intended Outcomes / Objectives:

1. 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).
2. 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
3. Senior chemistry majors in the biochemistry concentration will be able to demonstrate a **mastery of** modern factual knowledge in **Biochemistry**. cohort =CHMB

DRILL DOWN-----

RELATED ITEM LEVEL 1

Assessment: Learning Goal 1: ETS Chemistry Field Exam

Frequency of Assessment:

Annual

Rationale:

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)

RELATED ITEM LEVEL 2

Results: Learning Goal 1: ETS Chemistry Field Test

Results:

1. The national median varies each year between 147.0 and 149 (using nationwide institutional data) and 146.0-148.0 (using nationwide individual student scores). Thus, for example, in 2012-2013 our student average score of 152 was in the 60th percentile when compared to both institutional medians and individual score medians when compared to all of the students that took this exam (typically > 5000 students). The 2018-2019 National average was 148.

Test Date	Total	National
(Avg F/S)	TTU (Chemistry)	score %ile (institutional avg/individual score average)
2008-2009	146	43/48
2009-2010	145	45/40
2010-2011	147.1	51/46
2011-2012	144	50/43
2012-2013	152	60/60
2013-2014	151	60/60
2014-2015	152	61/63
2015-2016	150	58/61
2016-2017	146	49/39
2017-2018	146	49
2018-2019	148	50

(Comparison data is now the national average)

2. When compared to 227 other Universities median scores, TTU Chemistry graduates scores for critical thinking (Mean percent correct (2011-2018); 41, 44, 64, 48, 60 and 60, 48 and 40 respectively.

3. 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 have tracked these scores between 2007 and 2018. Likely in part due to the nature of this assessment indicator (where questions that relate to Biochemistry and pulled from the four actual sections of the Chemistry exam), our scores have been quite variable. For example, in the Fall of 2006, we scored in the 99 percentile, but in the following Spring (2007) we scored in the 76 percentile. The actual percentiles observed Spring 2009-Spring 2018 are 68, 82, 76, 61, 57, 57, 63, 52, 48 and 54. 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. Between 2009 and 2019, TTU students scored in the following percentiles; 61, 65, 71, 65, 69, 60, 63, 60, 64 and 65. For a regional, rural university, these are respectable percentiles.

Attachments:

Learning Goal 2: Demonstrate Computer Proficiency

Define Goal:

Demonstrate proficiency in using computers **to solve problems in chemistry.**

Intended Outcomes / Objectives:

Senior Chemistry majors in all concentrations will be able to **access computers** and **demonstrate proficiency** in using computers **to solve problems in chemistry.** cohort =CHMP, CHMB, CHMN (all areas).

DRILL DOWN-----

RELATED ITEM LEVEL 1

Assessment: Learning Goal 2: National Survey of Student Engagement (NSSE)

Frequency of Assessment:

Annual

Rationale:

Through monitoring the responses of freshmen and senior chemistry majors where students are asked how often they have worked an assignment where a computer was used, an increase should be observed. Faculty are encouraged at faculty meetings to continue to provide such exercises. cohort =CHMP, CHMB, CHMN (all cohorts).

RELATED ITEM LEVEL 2

Results: Learning Goal 2 - NSSE

Results:

Below is a compilation using a current assessment metric for 2009 and 2011 offered by the University. This data shows that more and more students in Chemistry are using computers during their tenure at TTU.

			2009		2011
NSSE Question (2009 and 2011)	Class Level	N	Mean	N	Mean
Number of problem sets (problem- based homework assignments) that take you MORE than an hour to complete	Freshman (1st Year)	12	3.25	7	3.29
	Senior (4th Year)	12	2.83	9	3.56
Institutional emphasis: Using computers in academic work	Freshman (1st Year)	13	3.46	8	3.75
	Senior (4th Year)	12	3.50	8	3.78

			2009		2011
NSSE Question (2009 and 2011)	Class Level	N	Mean	N	Mean
Practicum, Internship, field experience, co-op or clinical assignment	Freshman (1st Year)	13	3.00	8	2.75
	Senior (4th Year)	11	2.00	9	3.44
Worked with faculty on activities other than coursework outside of class	Freshman (1st Year)	13	1.77	8	1.75
	Senior (4th Year)	12	2.00	8	2.63
Work on a research project with a faculty member outside of class or program requirement	Freshman (1st Year)	13	2.38	8	2.63
	Senior (4th Year)	12	2.83	9	3.00

Culminating senior experience (capstone, senior project, thesis or comprehensive exam)	Freshman (1st Year)	13	2.54	8	2.13
	Senior (4th Year)	12	2.92	9	3.22

This is a completed item and will be replaced in 2020

Attachments:

Learning Goal 3: Successful Matriculation to Industry, Graduate and Professional Health Science Schools

Define Goal:

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

Intended Outcomes / Objectives:

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).

DRILL DOWN-----

RELATED ITEM LEVEL 1

Assessment: Learning Goal 3: Successful Matriculation to Industry, Graduate and Professional Health Science Schools

Frequency of Assessment:

Annual

Rationale:

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.

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

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 would be appreciate

RELATED ITEM LEVEL 2

Results: Learning Goal 3: Student Matriculation Annual Report Data

Results:

A combination of the Chemistry Department Annual Report and the Graduating Student Survey are used to compile a list of where our students go when they leave TTU. This is tabulated in the attached file as TTU Chemistry B.S. Graduates. Where are they now? Since 2008 we have had students gain entry and successfully matriculate from Universities and Professional Schools throughout the US and the nation. One of our recent graduates just completed his PhD at the University of Chicago and is now a post-doc at Northwestern and three of our Biochemistry graduates just completed medical school at the University of Alabama-Birmingham (UAB). Another chemistry graduate just finished his third year at the University of Virginia Medical School.

Attachments:

19GRADS.doc

Learning Goal 4: Integrate Chemical Knowledge with Research & Team-Based Learning

Define Goal:

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

Intended Outcomes / Objectives:

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).

DRILL DOWN-----

RELATED ITEM LEVEL 1

Assessment: Learning Goal 4: Integrate Chemical Knowledge with Research & Team-Based Learning

Frequency of Assessment:

Rationale:

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.

Also tabulated in the chemistry department annual report are published manuscripts, submitted grants and funded grants.

RELATED ITEM LEVEL 2

Results: Learning Goal 4: Integrate Chemical Knowledge with Research & Team-Based Learning

Results:

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. Since 2007, TTU chemistry has sent either the highest,

or the second highest number of undergraduate students to the national ACS meeting to present the results of their research. Since the ESS exam is no longer an available assessment tool, the department has used as a metric the number of students undertaking undergraduate research and the number of students disseminating that research at a national meeting as an assessment indicator. The following table tabulates the participation of undergraduates at the National meeting of the ACS.

Academic Year

	Students Active in Undergrad Research the National ACS Meeting	Research Presented at
2018-2019	71	22 (Orlando, Fl)
2017-2018 La)	74	19 (New Orleans,
2016-2017 Francisco, Ca)	72	15 (San
2015-2016 Ca)	77	26 (San Diego,
2014-2015	77	26 (Denver, Co)
2013-2014	72	22 (Dallas, Tx)
2012-2013 La)	71	15 (New Orleans,
2011-2012 Ca)	67	12 (San Diego,
2010-2011	53	17 (Anaheim, Ca)
2009-2010 Francisco)	40	14 (San
2008-2009 City)	41	12 (Salt Lake
2007-2008	32	12 (New Orleans)
2006-2007	28	13 (Chicago)
2005-2006	23	9 (Atlanta)

Attachments:

Learning Goal 5: General Chemistry Knowledge

Define Goal:

Demonstrate a thorough knowledge of general chemistry.

Intended Outcomes / Objectives:

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**.

DRILL DOWN-----

RELATED ITEM LEVEL 1

Assessment: Learning Goal 5: General Chemistry Exam

Frequency of Assessment:

Annual

Rationale:

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. It has been useful since it contains the scores of hundreds of students from a large number of Universities nationwide. Results are shared with faculty and discussed at faculty meetings and retreats. Comparable professionally equivalent, internally generated exams are now created and in those cases, student improvement is based on year-to-year performance.

RELATED ITEM LEVEL 2

Results: Learning Goal 5: General Chemistry Exam

Results:

Beginning Spring 2013, we began offering the GenChem13 ACS exam, thus, a new assessment cycle commenced. The National norm of the new exam is 52. Beginning Fall 2017, we initiated a professionally equivalent exam and give this exam each semester.

2013-Present TTU General Chemistry Assessment (National Norm=52.0%)

Year	Average Score	Year	Average Score
2013	52.8	2017	51
2014	56.3	2018	54
2015	57.2	2019	53
2016	59.0	2020	

Beginning in 2017-2018, we are now using our own professionally equivalent exam (internal) for assessment. This exam will be used for 5 years to track student success that results from continuing modifications.

Results:

Final exam results for CHEM 1110 & 1120 are shown below. The exams are the same for each semester, but different for each course. The exams were constructed largely based on questions written for the standard hour exams over the previous four year period for which the individual item statistics were favorable in terms of discrimination index (separating the higher achieving students from those who are not) and overall difficulty.

Table 1 – Tabulation of Final Exam averages in CHEM 1110 & 1120

	CHEM 1110	CHEM 1120
FALL 2016	60.2	N/A
SPRING 2017	50.3	50.9
FALL 2017	60.0	42.7
SPRING 2018	50.9	53.6

To monitor student retention, the percentage of students receiving unsatisfactory letter grades (D, F, or W) in CHEM 1110 and 1120 over the past three academic years is tabulated below.

Table 2 – Tabulation of D/F/W Rates in CHEM 1110 & 1120

FALL	CHEM 1110	CHEM 1120	SPRING	CHEM 1110	CHEM 1120
2015	38.7%	59.0%	2015	N/A	N/A
2016	32.7%	18.3%	2016	56.3%	44.4%
2017	42.7%	52.0%	2017	49.8%	34.2%
2018	N/A	N/A	2018	47.0%	35.6%

Results (2018-2019):

Final exam results for CHEM 1110 & 1120 are shown below. The exams are the same for each semester, but different for each course. The exams were constructed largely based on questions written for the standard hour exams over the previous four year period for which the individual item statistics were favorable in terms of discrimination index (separating the higher achieving students from those who are not) and overall difficulty.

Table 1 – Tabulation of Final Exam averages in CHEM 1110 & 1120

	CHEM 1110	CHEM 1120
FALL 2017	60.0	42.7
SPRING 2018	50.9	53.6
FALL 2018	59.3	N/A
SPRING 2019	51.1	53.0

Attachments:

Program Goal 1: Increase External Funding

Define Goal:

Increase external funding.

Intended Outcomes / Objectives:

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

DRILL DOWN-----

RELATED ITEM LEVEL 1

Assessment: Program Goal 1: External Funding

Frequency of Assessment:

Annual

Rationale:

Chemistry Department annual reports external research funding level in the department each year.

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**.

Funding opportunities (Program Goal 1) are **discussed at faculty meetings** or **distributed via email**. The chair will also make subsets of faculty **aware of funding opportunities** as he

receives them from various institutional sources, such as the Office of Research, The Water Center, the American Chemical Society, or the Dean of Arts & Sciences.

RELATED ITEM LEVEL 2

Results: Program Goal 1: External Funding

Results:

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 \$121K per year 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 Reports through 2018).

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
Total last 13 years	\$ 6,694,769	\$2,341,000

Attachments: