UNIT REPORT

Chemistry BS - Institutional Effectiveness Final Annual Report 2019

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Chemistry BS

Department of Chemistry Mission Statement

Reporting Year: 2018-2019

Providing Department: Chemistry BS

Department/Unit Contact: Jeff Boles

Mission/Vision/Goal 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

Reporting Year: 2018-2019

Providing Department: Chemistry BS

Department/Unit Contact: Jeff Boles

Mission/Vision/Goal 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.

Outcome 1: Mastery of Factual Knowledge

Define Goal:

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).

Intended Outcomes / Objectives:

Outcome 2: High Level of Critical Thinking

Define Goal:

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

Intended Outcomes / Objectives:

Outcome 3: Mastery of Modern Factual Knowledge in Biochemistry

Define Goal:

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

Intended Outcomes / Objectives:

Outcome 4: Demonstrate Computer Proficiency

Define Goal:

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).

Intended Outcomes / Objectives:

Outcome 5: Successful matriculation to Industry, Graduate and Professional Health Science Schools

Define Goal:

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).

Intended Outcomes / Objectives:

Outcome 6: Integrate Chemical Knowledge with Research & Team-Based Learning

Define Goal:

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).

Intended Outcomes / Objectives:

Outcome 7: CHEM 1110/1120 Final Exam Score Improvement

Define Goal:

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**.

Intended Outcomes / Objectives:

Program Goal 1: Increase External Funding

Define Goal:

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

Intended Outcomes / Objectives:

Program Goal 2: Chemistry Department Advisory Board Growth and Utilization Expansion

Define Goal:

Establish and strategically expand the Chemistry Department Advisory Board.

Intended Outcomes / Objectives:

Assessment: Chemistry Department Annual Report

Goal/ Outcome/ Objective: Outcome 5 & 6, Program goals 1 & 2

Type of Tool: Annual Unit Report

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.

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

Chemistry Department Advisory Board growth, expansion and utilization is also tabulated in the department's annual report as well as discussed at faculty meetings and/or retreats. A Chemistry advisory board (Program Goal 2) will help us with curriculum evolution as well as with targeted fund-raising. Such changes to the curriculum is also discussed at faculty meetings/retreats.

Assessment: ETS Chemistry Field Exam

Goal/ Outcome/ Objective: Outcome 1, 2 & 3

Type of Tool: Exit 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)

Assessment: Graduating Senior Survey

Goal/ Outcome/ Objective: Outcome 6

Type of Tool: Survey

Frequency of Assessment: Annual

Rationale:

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

Graduating Senor Survey is provided for review below.

TTU DEPARTMENT OF CHEMISTRY GRADUATING SENIOR SURVEY

Major: **Emphasis Area:** **Advisor:**

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

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

1 = Poor 2 = Fair 3 = Good 4 = Excellent 5 = Not applicable to me

Quality of courses in preparing me for employment/graduate school 1 2 3 4 5
Quality of instruction in:
General Chemistry
Organic Chemistry
Analytical Chemistry
Inorganic Chemistry
Physical Chemistry
Biochemistry
Fairness in grading my courses
Availability of required courses
Opportunity for student evaluation of instruction
Quality of general education courses
Organization and clarity of curriculum requirements

Opportunities for personal interactions with faculty
Opportunities for students to participate in faculty research
Availability of advisor
Willingness of advisor to assist
Quality of curricular advising in chemistry
Quality of career advising in chemistry
Quality of classroom facilities
Quality of laboratory facilities
Quality of TTU library chemistry holdings
Quality of computer support
Availability of professional activities or clubs in the department
Assistance given be departmental secretary
Assistance given by stockroom manager
Quality of my initial contact with the department
Opportunity for student participation in departmental decisions
Overall quality of the department
Overall satisfaction with degree program

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

Attached Files
Graduating Senior Survey

Assessment: Internally Generated General Chemistry Exams (professionally equivalent to ACS National Exams)

Goal/ Outcome/ Objective: Outcome 7

Type of Tool: National Accrediting Agency Requirements and Standards

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.

Assessment: National Survey of Student Engagement (NSSE)

Goal/ Outcome/ Objective: Outcome 4

Type of Tool: Focus Group

Frequency of Assessment: Annual

Rationale:

Initially the Enrolled Student Survey was used for as an assessment tool, however, that tool was replaced with the NSSE in 2009. This tool is useful to collect information related to computer use by students.

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).

Assessment: SciFinder Scholar

Goal/ Outcome/ Objective: Program Goal 1

Type of Tool: Other

Frequency of Assessment: Annual

Rationale:

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.

Results: Chemistry Advisory Board

Goal/Objective/Outcome Number: Program Goal 2

Results:

As indicated in the Chemistry Department Annual Report, **Program Goal 2 is being met**, as several board members were identified and currently serve in a strategic manner. In Spring 2016, Dr. Sullivan Smith was added to our board and serves as a Health-Science representative. In Fall 2017 Glenn Everett (Tennessee Bureau of Investigation) was added as a Forensic representative. No additional members have been added since the addition of Glenn Everett.

Attachments:

Results: ETS Chemistry Field Test

Goal/Objective/Outcome Number: Outcome 1, 2 & 3

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 (Avg F/S)	Total TTU (Chemistry)	National 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:

Results: External Funding

Goal/Objective/Outcome Number: Program Goal 1

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:

Results: NSSE

Goal/Objective/Outcome Number: Outcome 4 and Outcome 6

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
Question	**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	9	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:

Results: Chemistry Department Annual Report Data Excerpts

Goal/Objective/Outcome Number: Outcome 5 & 6 and Program Goal 1

Results:

Outcome 5: 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.

Outcome 6: 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. NSSE data, as well as Graduating Student Surveys also further illustrate the availability of research as seen through the eyes of a subset of freshmen and graduating chemistry majors in 2009 and 2011. Of those that

took the NSSE survey in 2009 and 2011, an increase is noticed in the number of upperclassmen planning to conduct some form of undergraduate research demonstrating students are becoming more and more aware of these opportunities.

Academic Year

	Students Active in Undergrad Research	Research Presented at the National ACS Meeting
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)
2012-2013	71	15 (New Orleans, La)
2011-2012	67	12 (San Diego, Ca)
2010-2011	53	17 (Anaheim, Ca)
2009-2010	40	14 (San Francisco)
2008-2009	41	12 (Salt Lake City)
2007-2008	32	12 (New Orleans)
2006-2007	28	13 (Chicago)
2005-2006	23	9 (Atlanta)

Program Goal 1: Additional tabulated departmental funding results are shown under an additional results tab.

Attachments: Attached Files

Where are they now 2016

Results: General Chemistry Exam

Goal/Objective/Outcome Number: Outcome 7

Results:

Results of the ACS General Chemistry exam are shown in the table below:

2003-2010 TTU General Chemistry Assessment (National Norm=47.7%)

Year	Average Score	Year	Average Score
2010	49.6	2006	52.1
2009	52.1	2005	52.0
2008	51.0	2004	53.0
2007	51.8	2003	50.0

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:

Modifications and Continuing Improvement: Outcome 1

Goal/Objective/Outcome Number: Outcome 1

Program Changes and Actions due to Results:

For Student Learning Outcome 1, as assessed by the ETS Field exam for student performance in chemistry, the department continues to stress the importance of introducing new pedagogy in the classroom. The department formed an ad hoc committee to develop a platform for enhanced chemistry learning/tutoring through exploitation of desire-2-learn and PenCasts (Chemical Solutions). Laboratory equipment purchased with funds provided to the science departments in the College of Arts and Sciences are used to a greater extent in upper division chemistry classes. Those funds have been used to purchase an FTIR instrument, a Gas Chromatograph, a Raman Spectrometer and an Ion Chromatograph in order to enhance upper division laboratory experiences and undergraduate research. The department recently purchased an evaporative light scattering detector (ELSD) for a liquid chromatograph and a new FT-Infrared Spectrometer. These funds were also used to purchase the appropriate hood enclosures for working with both prokaryotic and eukaryotic cell lines to enhance cross-disciplinary studies in both academic labs and research labs. We also purchased a gel imaging system. These activities will continue as we move forward. External funding has also been sought: Faculty received funding for the purchase of a Bioanalyzer, a PCR machine and a NanoDrop spectrometer from NSF to further enhance these laboratory experiences. A team led by Dr. Carrick was successful obtaining an NSF-MRI grant to purchase a new NMR with a cryo-probe. This provides a giant step forward in organic chemistry, inorganic chemistry and biochemistry. In addition, a greater number of students started carrying out undergraduate research during the academic year - oftentimes utilizing this newly acquired instrumentation in their research. Funds have also been acquired from the Department of Energy to acquire automated flash chromatography and stop-flow spectrophotometric analysis.

Link to Assessment:

Link to 'Tech Tomorrow' Strategic Plan: Diverse Faculty and Staff
Programs, Certificates, and Training

Modifications and Continuing Improvement: Outcome 2

Goal/Objective/Outcome Number: Outcome 2

Program Changes and Actions due to Results:

For Student Learning Outcome 2, as assessed by the ETS Field Exam, we continue to stress the importance of **undergraduate research** as a means by which students can **increase critical thinking and problem-solving ability**. In the last two years, as a result of these efforts, we have been maintaining approximately 50% of all of our students involvement in undergraduate research **(Flight Plan Link: Improve Undergraduate Experience)**. It is possible that the increase in numbers of students undertaking undergraduate research and being exposed to the advanced instrumentation in Learning Outcome 1 may have contributed to our higher score this past year. In addition, **additional guided-inquiry experiments** have been added to laboratory experiences in General Chemistry and Biochemistry. We plan to once again hold our research mini-symposia in September 2019 in hopes to attract many new Freshmen and Sophomores into the research labs (regardless of major).

Link to Assessment:

ETS Field Exam for Chemistry

Link to 'Tech Tomorrow' Strategic Plan: Programs, Certificates, and Training

Modifications and Continuing Improvement: Outcome 3

Goal/Objective/Outcome Number: Outcome 3

Program Changes and Actions due to Results:

For Student Learning Outcome 3, as assessed by the **ETS Field exam** and the **National ACS Biochemistry Exam**, we have continued the **addition of a section of CHEM 4610/4620** which initially **reduced the student-to-teacher ratio** to only up to 40 students per section. Now that we do this each year and offer a trailer section in the Spring semesters, the student-to-teacher ration has dropped further. **Our scores on the** ACS standardized exam have remained about the same. In order to improve these scores, the department started utilizing a more advanced text book authored by Garrett & Grisham (Brooks/Cole Publishing). During 2013-2014 we added online homework in Biochemistry (same text) which was well-received by the students. This was continuted during 2014-2015 and 2015-2016. During 2017-2018 we are moving to the new edition of this textbook (6th edition), and as a consequence, we moved to Owl 2.0 for assisted learning and online homework. We continue to use OWL 2.0 in 2018-2019.

Link to Assessment:

Link to 'Tech Tomorrow' Strategic Plan: Programs, Certificates, and Training

Modifications and Continuing Improvement: Outcome 4

Goal/Objective/Outcome Number: Outcome 4

Program Changes and Actions due to Results:

For Student Learning Outcome 4, as assessed by the National Survey of Student Engagement (NSSE) for **proficiency and use of computers** , we **promote the use of email, D2L (iLearn) and computer-based assignments as supplemental aids** to instruction. We continued to use **online homework** in general chemistry and began implementing this type of system in **upper division courses**, such as Analytical Chemistry (2010), Organic Chemistry (2012) and Biochemistry (2013). We switched to WebAssign online homework for two years in general chemistry, but after multiple problems with the company, and a lack of student improvement, we switched back to using OWL online homework in General Chemistry. In Fall 2014, in hopes of further improving student success, we moved to the "atoms first" teaching pedagogy as well as an advanced online homework system. More **new experiments were implemented based on modern computer-interfaced instrumentation**, such as the acquisition of the MeasureNet system in General Chemistry ($100K). The MeasureNet system allows for a greater number of guided-inquiry type experiments furthering the computational experience of TTU students taking Chemistry classes. A new team-taught course in **computational chemistry was added** to the curriculum in 2012 and has continued. The Enrolled Student Survey was abandoned by TTU shortly after 2005-2006. It was replaced by the NSSE survey for which we have 2009 and 2011 data at this time. As a result of the prior ESS data, faculty in the department of Chemistry continued to increase the use of computers in instruction. This has included on-line homework in multiple classes, the requirement of utilizing spreadsheets in general chemistry, and increasing use of computers via on-line literature searches required in multiple classes, etc. As we plan our move to the new science building, we will move to a new data-acquisition platform. Assessment will be a key focus as those lab activities are planned.

Link to Assessment:

Link to 'Tech Tomorrow' Strategic Plan: Diverse Faculty and Staff
Programs, Certificates, and Training

Modifications and Continuing Improvement: Outcome 5

Goal/Objective/Outcome Number: Outcome 5

Program Changes and Actions due to Results:

Student Learning Outcome 5, as assessed by a combination of the Chemistry Department Annual Report and the Graduating Student Survey, now addresses all of our concentrations in Chemistry (CHMA, CHMP, CHMB and CHMN) since degree certification requirements changed in 2008. This learning outcome has been successful. **Students from all** of the above **concentrations** are leaving TTU to **attend graduate and professional schools**. In order to further increase the success of our students, we have made **career options more available** to students through expanded board space in high traffic hallways for postings of relevant coop and intern experiences, graduate school posters, and some types of job postings. Faculty have been formally put in charge of this and post these opportunities on bulletin boards in hallways and classrooms. The **additional importance placed on undergraduate research** since 2007 has raised the awareness of the importance of planning for graduate and professional schools. In 2008, the department initiated the **Student Research Development Grant program**, an in house program that provides opportunities for students to write research grants, submit them for review, carry out their proposed research and disseminate their research. In the last two years, **~$50,000 has been awarded to successful students (2015-2019)**.

Link to Assessment:

Annual Report and Graduate Student Surveys

Link to 'Tech Tomorrow' Strategic Plan: Adult Learners

Modifications and Continuing Improvement: Outcome 6

Goal/Objective/Outcome Number: Outcome 6

Program Changes and Actions due to Results:

As also described in the Chemistry Department Annual Report, we have made excellent progress towards Student Learning Outcome 6 by continuing to take an active role in **promoting involvement of every qualified undergraduate major in an undergraduate research project with a faculty member**. Beginning in 2007, we initiated a **Fall research mini-symposia** followed by a **cook-out social** for the purpose of **making undergraduates more aware of research opportunities** in the department. Multiple faculty give 10-15 minute presentations about project opportunities in their labs. This resulted in an immediate increase in the number of students both carrying out research in faculty labs, but also in the number of students presenting the results of their research at scientific meetings (see assessment results). We continue to keep students informed about summer research activities in government, industrial and academic research laboratories. Faculty encourage their

students to apply for coop and internship experiences, and **apply for Chapter 606 funds for undergraduate research projects**, in addition to the **Student Research Development Grants (SRDG) mentioned in Learning Outcome VI**. In 2008, the year the SRDG was initiated, $2,800 was awarded; in 2009, $5,600 was awarded and in 2010, $10, 543 was awarded. In Fall 2011, an additional $4,185 was awarded during the first of four submission dates during the 2011-2012 academic year. Funds awarded during 2012-2013 exceeded $11,000 as they did during 2013-2014 and 2014-2015, 2015-2016 and 2016-2017. The funds awarded in this program are generated through the sale of department-authored laboratory manuals. We also take advantage of the Jackson/Swindell Undergraduate Research Award program and have funded at summer stipends to assist additional students remain on campus throughout the summer to carry out undergraduate research. During 2017-2018, two students applied for and received this grant. During 2018-2019, the SRDG awarded **$15,467.00 with an average award of $1,933.00.** One Swindell-Jackson award was granted and fop the first time, a Kline award was granted in support of research.

Link to Assessment:

Annual Report

Link to 'Tech Tomorrow' Strategic Plan: Programs, Certificates, and Training

Modifications and Continuing Improvement: Outcome 7

Goal/Objective/Outcome Number: Outcome 7

Program Changes and Actions due to Results:

For continued success in Student Learning Outcome 7, the department feels that our students should be able to **outperform the established national norms (50.2% average score) on the National ACS General Chemistry Exam on a consistent basis. In 2017 we switched to an in-house professionally equivalent exam and will use that for five years for assessment**. In order to firmly establish this goal as a trend, the department has continued its prior actions of utilizing on-line homework for assessment, adding additional guided-inquiry experiments in the lab component of the course and utilizing the MeasureNet data acquisition system coupled to PC's in the lab to further enrich student experience. In 2014-2015 we moved to the "Atoms First" teaching pedagogy for General Chemistry which also included an online homework component. We continued using the atoms first approach during 2017-2018 and will did so during 2018-2019, as well. Scores on the ACS exam have been consistently above or at the national average (see Table under Results for trends). In 2007, the department initiated a new course, CHEM 1000 which we initially called JumpStart Chemistry (it's actually a principles course which strengthens a student's ability to use algebra to solve chemistry problems). Incoming new students with a weak or no background in chemistry have the opportunity to take this course before they take the CHEM 1110/1120 sequence. Students are also allowed to transfer into this course if they are trying but failing CHEM 1110. Retention of these students was initially very high following completion of CHEM 1000. The first cohort of 16 students graduated in Spring 2011 (100%) and all were retained in STEM majors, although two of those ended up with Nursing degrees. The assessment and development of CHEM 1000 also continues.

CHEM 1110-1120 Specific Modifications for Continuing Improvement (as recorded end of 2018-2019 academic year)

The results of the final exams are analyzed and broken down in terms of broad topics and individual questions. From these results, the faculty are encouraged to strategically alter their approaches to enhance outcomes for content areas, targeted to the topics identified as having the lowest success rates according to the analysis and high impact content throughout the chemistry degree curricula at TTU. This protocol will be enhanced by research projects being undertaken by graduate students designed to identify commonalities between low-performing items/groups on the final exams to allow faculty to make more targeted changes with a broader impact. Additionally, student learning outcomes (SLOs) have been developed and will be tied to assessment outcomes making progress easier to track and provide more clarity to the skills expected of students in the course.

After a lengthy evaluation process that involved piloting new software in the CHEM 1110 lectures during the Spring 2019 semester and class tests with the CHEM 1120 Honors recitation, a new homework system will be implemented based on faculty observations and survey results provided by students. The ALEKS system is unlike a traditional homework system in that it directs student studying toward topics for which they have not demonstrated mastery, and guides students through supporting topics to provide the best possible chance for success in attempting more challenging problems. The faculty felt this was the strongest software solution on the market, and it specifically seemed to help conscientious students who are willing to put forth effort but need more structured study plans than what the faculty can reasonably provide given the scale of the program.

Building off of faculty projects, video tutorials will be incorporated into the CHEM 1110/1120 lecture and laboratory curricula to support important learning objectives and goals. Student-created lab video tutorials will be tied into the laboratory curriculum as required viewing to better prepare students before coming to lab. Faculty-created video tutorials have been produced to target troublesome concepts with the goal of providing on-demand instruction in an increasingly digital learning environment, and this stable of resources will continue to be expanded throughout the academic year.

As part of a research project, the training regimen for General Chemistry teaching assistants will be bolstered in an effort to better prepare the TAs for their responsibilities. Since the TAs have direct interaction with the students in the laboratories, this has the potential to have a significant positive impact on program outcomes. TAs who are better prepared can more fully engage the students in the content, and students should respond favorably to TAs who are more capable of answering their questions in a more competent manner.

An additional research project undertaken by an MS student in the department has yielded a molecular modeling exercise that was piloted in the summer and will be initiated fully in CHEM 1120 lab in Fall 2019. This exercise introduces students to aspects of organic chemistry that they normally would not see in CHEM 1110 or 1120, and should provide a review of important bonding concepts relevant to the CHEM 1120 curriculum. Delivering the content through a modeling exercise also exposes students to a branch of chemistry they may not have been aware of previously, which could be more attractive to a broader audience, therefore increasing interest in the subject, which could lead to more motivated students and stronger outcomes.

Link to Assessment:
In house generated or national ACS chemistry exams
Link to 'Tech Tomorrow' Strategic Plan: Programs, Certificates, and Training

Modifications and Continuing Improvement: Program Goal 1

Goal/Objective/Outcome Number: Program Goal 1
Program Changes and Actions due to Results:
For continued success in Program Goal 1, as assessed by the **Chemistry Department Annual Report (indirect assessment) and SciFinder Scholar (direct assessment)**, grant writing by the faculty has been **strongly encouraged and successful**. NSF-CCLI instructional grants have been submitted and funded in order to obtain needed laboratory equipment to be used in research and teaching laboratories. **Release time from teaching** has been given to faculty receiving external funding for research. A **differential teaching load was implemented** to give faculty hours for grant writing, involvement of students in research, extensive service activities, and so forth. Several new faculty have recently been hired and each is required to **vigorously pursue the acquisition of external funding**. During 2015-2016 an interdisciplinary grant funded by NSF (~$600,000) provided the campus advanced NMR resources. We will continue to submit grant proposals to improve instrumentation infrastructure.

Link to Assessment:
Chemistry Department Annual Report (indirect assessment) and SciFinder Scholar (direct assessment)
Link to 'Tech Tomorrow' Strategic Plan: Alumni/Friend Engagement

Modifications and Continuing Improvement: Program Goal 2

Goal/Objective/Outcome Number: Program Goal 2
Program Changes and Actions due to Results:
To continue to be successful in Program Goal 2, additional board members will be identified in a strategic manner as needs are identified, as indicated in the Chemistry Department Annual Report. The decision was made to form the board slowly over time as opportunities arose. Thus, **the board is growing** as alumni are positioned to assist the department with growth in a strategic manner. The board was initiated in 2007-2008 when we sought to add several concentrations within the Chemistry Degree and when we initiated the Analytical Services Program in the Department. For example, **an alumnus (retired from Tennessee Eastman)** was added and **assisted with our development of a Business Chemistry Degree**. He has visited the department regularly in the past four years, speaks to students and serves as an Alumni Mentor. **Another alumnus (Tennessee Bureau of Investigation)** visits the department regularly, **speaks to students and serves as an Alumni Mentor**, as well. He **assisted with the development of our Forensic Chemistry Degree**, and according to him, it's the only degree in the State of Tennessee that exactly meets their criteria for hire without the need for much additional training. **An additional alum was**

selected this past year (2015-2016) to represent Health Science Chemistry and our Industrial Chemistry (Shell Oil) member remains on the board. We are currently pursuing a board member to represent Biochemistry and Environmental Chemistry, but the type of individual has not been strategically identified at this time. As our needs and opportunities grow, so will the alumni board.

Link to Assessment:

Analytical Services Program

Link to 'Tech Tomorrow' Strategic Plan: Alumni/Friend Engagement

Programs, Certificates, and Training