Institutional Effectiveness

2018-2019

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 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.

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**.**

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).

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

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.

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**.**

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.

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

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. 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.

2. *CHEM 1110 & 1120 Final Exams*

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

Results:

PG 1: Increase external funding

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

SLO 1: Demonstrate knowledge and critical thinking

Mean scores for ETS Chemistry Exam by Sub-test

	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019
# of students	*7*	*11*	*2*	*21*	*5*	*21*
1. Physical Chemistry	43	45	25	42	41	53
2. Organic Chemistry	44	45	33	48	46	55
3. Inorganic Chemistry	49	50	31	46	44	57
4. Analytical Chemistry	50	46	35	45	44	57
National Score	49	49	49	49	50	50
TOTAL	146	146	129	146	143	157

Mean scores for ETS Chemistry Exam Critical Thinking and Reasoning

	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019
# of students	*7*	*18*	-	*22*	*5*	*21*
Critical Thinking and Reasoning	40	41	-	38	35	52

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 now. 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.

Mean scores for ETS Chemistry Exam Biochemistry Aspects

	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019
# of students	*7*	*18*	-	*22*	*5*	*21*
ETS Biochemistry Aspects (Mean)	51	46	-	53	48	57

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. For a regional, rural university, these are respectable percentiles.

Percentiles for ETS Biochemistry Aspects and ACS Biochemistry exam

	2016	2017	2018	2019
ETS Biochemistry Aspects (Percentile)	63	52	48	54
ACS Biochemistry Exam (Percentile)	63	60	64	65

SLO 2: Successful graduates

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.

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. 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	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)

SLO 4: Knowledge of general chemistry

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.

2013-2016 GenChem 13 ACS exam (National Norm=52.0%)

Year	Average Score
2013	52.8
2014	56.3
2015	57.2
2016	59.0

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.

TTU General Chemistry Assessment

Year	Average Score
2017	51
2018	54
2019	53

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.

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

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.

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%

Modifications for Improvement:

PG 1: Increase external funding

Grant writing by the faculty will be more strongly encouraged. Release time from teaching will be given to faculty receiving external funding for research. The differential teaching load will be adjusted with respect to grant writing endeavors, involvement of students in research, extensive service activities, and so forth.

SLO 1: Demonstrate knowledge and critical thinking

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.

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). A new one-year course, will be offered in 2019-2020, Undergraduate Research Methods I and II has also helped attract additional students to undergraduate research.

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 ratio 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 continued 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.

SLO 2: Successful graduates

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 four years, ~$50,000 has been awarded to successful students (2015-2019).

SLO 3: Integrate chemical knowledge and team work

As also described in the Chemistry Department Annual Report, we have made excellent progress towards Student Learning Goal 4 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.

SLO 4: Knowledge of general chemistry

For continued success in Learning Outcome 5, 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.

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