Chemical Engineering BS: 2018-2019

TTU Mission

Providing Department:
Chemical Engineering BS

Department/Unit Contact:
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Mission/Vision Statement:

The Department of Chemical Engineering at Tennessee Technological University strives to develop the 21st Century Renaissance Engineer through development and implementation of novel learning environments anchored by the award-winning Renaissance Foundry Model. The foundation of this platform is rooted in the guidelines provided by the National Academy of Engineering's Vision for the Engineer of 2020. Educational protocols within the department are consistent with the mission and vision statements given below:

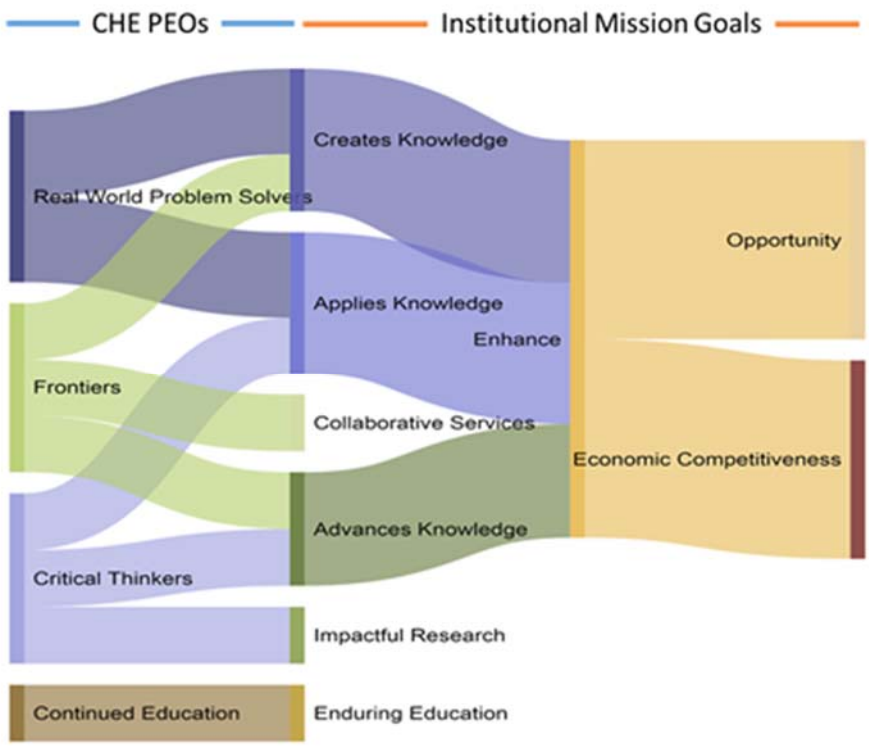
The **Mission** of the Department of Chemical Engineering is to prepare relevant and adaptive chemical engineers in state-of-the-art areas by emphasizing real-world problem solving and critical thinking skills. The **Vision** of the Department of Chemical Engineering is to be a recognized leader in chemical engineering education through excellence in teaching, research, and service.

The current Program Educational Objectives (PEOs) stipulate that within roughly five years that our graduates will collectively exhibit the following traits:

- Be real-world problem solvers (RWPS): the graduates of our program will obtain positions such as plant process engineer, design engineer, group leader, production engineering, sales engineer.
- Be critical thinkers (CT): the graduates of our program will demonstrate that they consistently make informed decisions through a process wherein they utilize critical thinking skills.
- Have continued their formal education (CFE): our graduates will demonstrate that they have continued their education beyond the BS through some form of professional development (not necessarily leading to another degree) or will have graduated from a professional school with an MS, PhD, MD, JD or similar degree.
- Be working at the frontiers in ChE (FChE): graduates from our program will utilize and apply technologies such as biomaterials, nano- and micro-systems, multi-scale analysis, informatics, group dynamics, and multi-media.

These objectives (considered herein to be synonymous with "Program Goals") are consistent with the TTU mission and vision. The figure below illustrates a clear association between the Program Goals and the institutional mission statement. Program Goal 1, real-world problem solvers, is mapped to two institutional mission goals: creates knowledge and applies knowledge. Program Goal 2, critical thinkers, is mapped to: applies knowledge / advances knowledge and impactful research (since critical thinking is clearly associated with an ability to apply, advance, and have impact). Continuing education, Program Goal 3, is most directly linked to the institutional mission

to provide an enduring education. Finally, Program Goal 4, working at the frontiers in CHE, is linked to creating and advancing knowledge and working collaboratively since the frontiers are almost always at the interface between multiple disciplines.



Mapping for Institutional Mission Goals and CHE Departmental Program Goals

Student Outcomes a-k

Define Goal:

Intended Outcomes / Objectives:

3(a) KNOWLEDGE – an ability to apply knowledge of mathematics, science and engineering,

3(b) EXPERIMENT – an ability to design and conduct experiments, as well as to analyze and interpret data,

3(c) DESIGN – an ability to design a system, component, or process to meet desired needs,

3(d) TEAMS – an ability to function on multi-disciplinary teams,

3(e) FORMULATE – an ability to identify, formulate, and solve engineering problems,

3(f) ETHICS – an understanding of professional and ethical responsibility,

3(g) COMMUNICATE – an ability to communicate effectively,

3(h) GLOABL – the broader education necessary to understand the impact of engineering solutions in global and societal context,

3(i) LIFE-LONG-LEARNING – a recognition of the need for, and an ability to engage in life-long learning,

3(j) CONTEMPORARY ISSUES – a knowledge of contemporary issues,

3(k) TOOLS – an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

DRILL DOWN----------
RELATED ITEM LEVEL 1

Assessments: SOs a-k

Frequency of Assessment:
Annually

Rationale:

FE Exam (Each Semester) Student Outcome While not a complete assessment tool in itself, the Fundamentals of Engineering (FE) exam does provide an objective, nationally-normalize test of certain engineering, math, and science topics, as well as the ability to analyze, formulate, and solve engineering problems, SO3e. Consequently, the FE exam has been used since 2002 as a measure of Student Outcomes.

Senior Survey (Annually) Student Outcomes a-k. The senior survey provides the opportunity for student feedback (anonymously) on different aspects of the program student outcomes, the CHE curriculum, and the student's experiences while at TTU. In addition, a number of questions are directly related to specific SOs across the a-k and the PEOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational

External Review of Senior (capstone) Design Projects (Each Semester) Student Outcomes a, c, d, e, g, h and k. External evaluators are invited to access the quality of the Senior Design Projects and to provide feedback on the capstone Design course. The evaluators ask questions of the team members and provide feedback on the technical quality of the projects and oral presentations using an established ABET Criteria-based rubric.

Course Level Assessment: (Every term a course is taught). Student Outcomes a-k. The Department uses selected courses to learn about student performance at the different levels of the curriculum, refer to attached table. Course-level assessment is done every term in which the course is taught and an Overview is assembled every third year. Those overviews are used to continuously improve the course and curriculum as a whole and are discussed with the departmental faculty and appropriate actions

Co-Op Report Assessment: (Semi or annually) Student Outcomes a-k. The Department uses a survey report directly written by the students' supervisor at the co-op site to learn about important student competences. The questionnaire requires responses for each of the (a) through (k) student

CHE External Advisory Board, BOA, (Annually). Student Outcomes a-k. The CHE External Advisory Board consists of between 18 members selected primarily from employers of our students, related industries and accomplished alumni. BOA is an advisory group which provides input and feedback on various curricular and accreditation matters (ABET, SACS, THEC Graduate Program Review). Some BOA members also regularly serve as the External Evaluators for the Senior Design Projects. The BOA bi-annually meets with the students, in the absence of faculty, to gather input regarding student impressions across the (a) through (k) student outcomes, but not necessarily focusing on any particular student outcome. The data is gathered during a one-hour meeting in an informal setting and is communicated likewise to the faculty during an oral briefing session. At times the BOA may report in writing regarding select items, but that decision is left to them.

Table A.4.1a. Assessment processes used between August 2015 and August 2019, the frequency of application and expected level of attainment (rubrics).

	Assessment Process	Student Outcomes*	Assessment Frequency	Expected Level of Attainment
	Processes for Student Outcomes Assessment			
1	**FE Exam**	a, e	Students self-select to take the FE near the end of their course of study, i.e. as Seniors. The FE is administered bi-annually.	Pass Rate ≥ National Average
2	**Senior Survey**	a-k	A population of seniors is surveyed once every third year.	Likert ≥3/5
3	**External Assessment of Senior Design Projects**	a, c, d, e, g, h, k	Design II projects are externally assessed in the Spring of each year.	>60% (>70%)
4	**Course-Level Assessments**	a-k	Course-Level Assessments are completed for select courses every term in which they are offered, see Table 4.2	>60% (>70%)
5	**Co-Op Employer Assessments**	a-k	Co-Op employer assessment data is gathered for every student participating in co-op at the end of their internship. The collective data is evaluated every third year.	Likert ≥3/5
6	**External Advisory Board (BOA) Assessment**	a-k	The BOA gathers student feedback bi-annually and reports it to the department.	Generally Positive Qualitative Assessment

RELATED ITEM LEVEL 2

Results (for Critical Thinking)

Results:

Critical Thinking: Students taking CHE 3111 (Heat Transfer) and CHE 3121 (Fluid Mechanics) during the 2018-19 academic year were assessed for critical thinking skills via the Critical thinking Assessment Test (CAT) which is an NSF-supported instrument developed at TTU and based on four broad aspects of critical thinking: evaluation/interpretation of information, problem solving, creative thinking, and effective communication. The test, designed to be interesting and engaging for students, has questions derived from real world situations. Most of the questions require short-answer essay responses, and a detailed scoring guide as well as grader training, and multiple graders help insure good scoring reliability. While various assessment designs are possible, a pre- and post- exam strategy was used for these two courses. Specifically, given that the heat transfer course is taken in the first semester of the junior year and the fluid mechanics course is taken during the second semester of the junior year, all students in the heat transfer course took the CAT at the beginning of the fall semester. Then, roughly half of these students took the test at the end of the fall semester (thus providing an indicator of improvements in critical thinking during this semester) while the other half of students took the test again at the end of the fluid mechanics

course. Students in the heat transfer course who took the test pre and post that semester (n=25) showed an average, statistically significant increase in their "CAT Total Score" which increased from 16.80 to 18.64. Students who had taken both the heat transfer and the fluid mechanics courses and took the pre test at the beginning of the fall semester and the post test at the end of the spring semester (n=24) showed an even higher gain in the CAT Total Score which increased from 18.60 to 21.15. In addition to the CAT, students were evaluated in these and other courses using rubrics that were developed to assess creative inquiry, including critical thinking skills with positive results.

Attachments:

RELATED ITEM LEVEL 2

Results (from Alumni and Employer Surveys)

Results:

Alumni and Employer Surveys: A new strategy of survey collection has been decided upon that leverages the CHE Board of Advisors (BOA) which includes program alumni and employers. The new survey will contain questions directly related to the attainment of Program Goals. Written comments will also be collected. The surveys have not yet been administered.

Attachments:

RELATED ITEM LEVEL 2

Results (from Board of Advisors' Meetings)

Results:

CHE Board of Advisors (BOA) Feedback: The BOA meetings are held annually. The BOA generally documents its findings in the form of an Executive Summary. Their findings regarding student success and satisfaction are reported there. Recommendations are used specifically as feedback into the program's curricular change process; however, such are rarely made by the BOA. Broader programmatic issues are typically identified by the BOA and are used to influence elements, including but not limited to faculty numbers and institutional support.

In the November 2018 meeting with the BOA, faculty reported to the Board the following regarding the undergraduate curriculum:

- CHE is traveling a trajectory towards innovation with impact: Efforts include but are not limited to engineering at the borders of nursing and CHE, a focus on entrepreneurship, and an increase of students involved in undergraduate research.

- The department implements the Renaissance Foundry Model across the curriculum: As a result, the department displays a collaborative-centered and team-based approach to student learning with closely-integrated facilitator-based discussions and guidance.
- Commendations for the department: The recent Eagle Works Competition was won by CHE students, the undergraduate students have led us to another title as the Best Darn Major, and faculty mentoring has led to increased involvement in undergraduate research making CHE the leader of such efforts within the College of Engineering.
- Curriculum grants are allowing development of updated experiential learning opportunities for students: Creative inquiry through immersion experiences intended to enhance problem-identification strategies and prototype development to address specific learning challenges became the focus across three courses within the undergraduate curriculum after approximately $20,000 in funding was awarded via the TTU Enhanced Discovery through Guided Exploration (EDGE) Creative Inquiry Curriculum Grant Program. Such experiences offered students a more systematic approach to problem-solving strategies, ultimately enhancing their understanding of course material in an integrated fashion across the curriculum.

Following discussions, the Board provided the following feedback to the faculty regarding the undergraduate curriculum:

- The Board is excited by the leadership demonstrated by our students in the winning of the Best Darn Major award for five (four consecutive) years.
- Increased efforts with respect to faculty relationships with local industry are recommended to increase the number of companies recruiting CHE students at the career fairs as well as increase the number of alumni involved in classroom activities.
- A more systematic blending of programming is necessary across the curriculum.

Attachments:

RELATED ITEM LEVEL 2

Results (from Co-Op Performance Assessments)

Results:

Co-Op Performance Assessments: The Co-Op survey includes 12 questions which per the new ABET Student Learning Outcomes map to Outcomes 1, 3-5, and 7 (Note: Data collected for the 2017-18 and the 2018-19 reporting periods are currently being examined). The results of these surveys which consist of responses from employers for co-op student internships from spring 2008 to spring 2017 (refer to the 2016-17 report) are largely unremarkable. Survey questions are ranked on a 1 (lowest) to 5 (highest) scale. Our rubric is that no student receives a score lower than 3. On average (as shown in the attached file), scores are between 4 and 5 for most students with an occasional lower score. We conclude that co-op employers are satisfied with our students' performance across the board. Similarly, co-op final reports are 100% approved by the co-op supervisors. At this time, the survey that is used is a College-developed co-op survey that does not include questions related to knowledge (a), experimentation (b), design (c) and tools (k). Since most co-op students are sophomores and juniors, it seems that omitting questions related to

experimentation and design might be logical. For a detailed mapping of the survey skills assessed to the Student Learning Outcomes 1, 3-5, and 7, please see the table below:

Items Assessed on Co-Op Employer Survey

Survey Item	Skills Assessed
a	Efficiently manage their assigned duties and responsibilities
b	Demonstrate the ability to work independently
c	Demonstrate a commitment to professional development
d	Participate in activities that serve the profession and/or public
1	Work effectively with other employees
2	Identify, formulate and solve engineering problems
3	Understand professional and ethical responsibilities
4	Produce effective written communications
5	Deliver effective oral presentations
6	Understand the global/societal impact of engineering
7	Recognize the need for and engaging in life-long learning
8	Understanding contemporary engineering issues
RO	Relationship with Others
AL	Ability to Learn
OP	Overall Performance

Attachments:

RELATED ITEM LEVEL 2

Results (from Design and Capstone Experiences and Other Example Course Level Assessments)

Results:

Results from Course Level Assessment and Curriculum Improvement Reports (CLACIRs):

CHE 2020 (Intro to Chemical and Biological Engineering Analysis II)

Target rubric value: 70%

Overall Class Average Performance: 77% (This percentage indicates that the class average performance was above target rubric.)

No concerns were noted by the course instructor for the most recent iteration of the course. As there were no noted concerns, there were no recommendations by the course instructor for the most recent iteration of the course.

CHE 3010 (Thermodynamics of Chemical Processes)

Target rubric value: 80%

Overall Class Average Performance: 80% (This percentage indicates that the class average performance was at target rubric.)

The course instructor noted some conceptual deficiencies within project applications during the term. To address the deficiencies noted in the course project, the course instructor recommends providing periodic feedback to students during the project development instead of allowing students to work independently during the project development to avoid implementing course misconceptions.

CHE 3111 (Transfer Science I: Conduction, Radiation, Diffusion)

Target rubric value: 70%

Overall Class Average Performance: 79% (This percentage indicates that the class average performance was above target rubric.)

No concerns were noted by the course instructor in the most recent iteration of the course. As there were no noted concerns by the course instructor in the most recent iteration of the course, no remediation was proposed.

CHE 3121 (Transfer Science II: Fluid Mechanics)

Target rubric value: 70%

Overall Class Average Performance: N/A

Spring 2019: Not yet available at this time

CHE 4210 (Chemical Reaction Engineering)

Target rubric value: 70%

Overall Class Average Performance: 77% (This percentage indicates that the class average performance was above target rubric.)

The course instructor noted student deficiencies with respect to designing, executing and reporting on laboratory experiments as well as with student ability to execute a literature review. In order to address the noted concerns, the course instructor indicated a need for an improved integration of the laboratory and related resources to allow students to draw a more tangible connection to course concepts.

CHE 4240 (Chemical Engineering Capstone Laboratory)

Target rubric value: 70%
Overall Class Average Performance: 93% (This percentage indicates that the class average performance was above target rubric.)

The course instructor identified students to be weak in the project identification with respect to the identified topics' connection to global issues. The course instructor recommends improvements in student knowledge of global concepts for the upcoming terms. Suggestions for implementing the student awareness of such global concepts include strengthening communication of expected learning expectations and project outcomes as well as development of assignments and discussions that connect global issues to individual team projects.

CHE 4410 (Chemical Engineering Process Design I)

Target rubric value: 70%
Overall Class Average Performance: 84% (This percentage indicates that the class average performance was above target rubric.)

While many of the most recent iterations of this course have indicated efforts to strengthen student performance related to material balance concepts and written quality of work, the most recent cohort of students did not reflect the same trend. Ultimately, the cohort performed well with respect to the team reports and presentations, but individual performance did not demonstrate the same level of student competency. No recommendations by the course instructor were provided at this time as the variance seen in the most recent iteration of the course could possibly be attributed simply to the cohort of current students. More data will be collected over the coming terms and then the course instructor will reassess.

CHE 4420 (Chemical Engineering Process Design II)

Target rubric value: 70%
Overall Class Average Performance: N/A

Spring 2019: Not yet available at this time

CHE 1020 (Products, Process and Ethics)

Target rubric value: 70%
Overall Class Average Performance on Selected Program Outcomes: N/A

Spring 2019: Not yet available at this time

Attachments:

RELATED ITEM LEVEL 3

Faculty Studies and Pedagogical Strategies of New and More Effective Learning Approaches

Program Changes and Actions due to Results:

The process of transitioning the process analysis course sequence and the ethics course as reported on in the previous reports was completed. Also in this reporting period, changes to the CHE 3730 (CHE Operations) course were discussed, and the CHE 4240 (CHE Capstone Lab) course was redesigned based on feedback from the BOA and from the Chair Debriefings.

Link to Assessment:

These changes were initiated per findings related to course level assessments of student learning outcomes within the curriculum.

DRILL DOWN----------

RELATED ITEM LEVEL 2

Results (from FE Exam)

Results:

FE Exam: Because Professional Engineering (PE) is not emphasized by the chemical engineering community at large, neither academic (research) nor industrial, only a small number of CHE students self-select to take the FE exam. Further, licensure as a PE is seldom required by employers in CHE-related industries. FE Exam statistics for the 2018/2019 reporting period are not currently available. Given the small number of students self-selecting to take this exam, it is difficult to place statistical significance on the use of these data as a basis for improvements in the CHE department's student learning outcomes. It is proposed that the use of the FE Exam as an assessment tool be reconsidered. This item has been undergoing discussions during the current reporting period by the Faculty in the CHE department.

Attachments:

RELATED ITEM LEVEL 2

Results (from Student Survey and Chair Debriefing)

Results:

Student Surveys and Chair Debriefings: Student surveys were administered on the typical 3-year cycle during the previous reporting period. Thus, no new results are presented for that item here. Regarding feedback during Chair debriefings (and following input from the BOA), the feedback of the BOA indicated that the experiences in laboratories are going in the right path for correction and satisfaction of the students. The Department is still monitoring this situation very closely with the help of the Capstone Lab Coordinator. The Department continues monitoring and receiving feedback from the students for courses that were indicated as a concern. The mentoring activities that have been implemented in the recent past were further extended to include the sitting-in of a faculty in the class of a more senior faculty with active engagement.

Attachments: