# Chemical Engineering BS: 2019-2020

## Definition of Unit

**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:

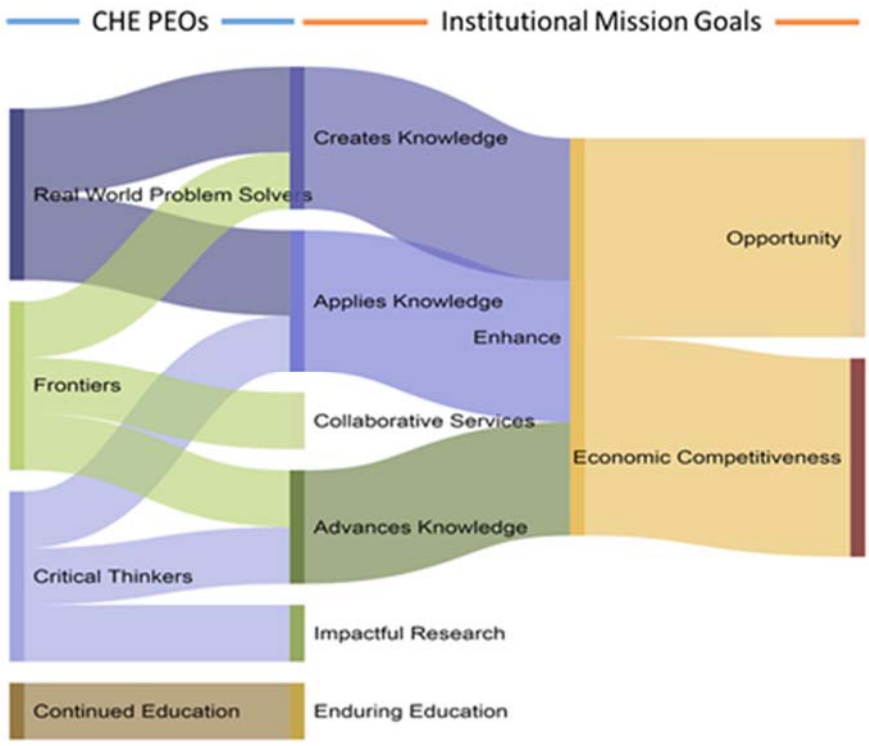
The **Mission** of the Department of Chemical Engineering is to prepare relevant and adaptive chemical engineers in state-of-the-art areas by emphasizing real-world problem solving and critical thinking skills. The **Vision** of the Department of Chemical Engineering is to be a recognized leader in chemical 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 engineer, 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): the graduates or our program 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): the graduates of our program will utilize and apply technologies such as bio materials, 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 Learning Outcomes: SOs 1-7

**Define Goal:**

**Intended Outcomes / Objectives:**

1. FORMULATE & SOLVE – an ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and
2. DESIGN for NEED, SAFETY, GLOBAL & SOCIAL FACTORS – an ability to apply engineering design to produce solution that meet specific needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. COMMUNICATE – an ability to communicate effectively with a range of
4. ETHICS – an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. TEAMS – an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.
6. EXPERIMENT, ANALYZE & INTERPRET – an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.
7. KNOWLEDGE ACQUISITION – an ability to acquire and apply new knowledge as needed, using appropriate learning

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

# Assessments: SOs 1-7

**Frequency of Assessment:**

Once every three years

**Rationale:**

**Senior Survey** (Annually) 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. In this way, feedbackisgatheredfromthestudentsectorofourconstituencyonbothstudentoutcomesand program educational objectives.

**External Review of Senior (capstone) Design Projects** (Each Semester) 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). 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 taken.

**Co-Op Report Assessment**: (Semi or annually) 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 1 through 7 student outcomes.

**CHE External Advisory Board, BOA,**(Annually).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 theabsenceoffaculty,togatherinputregardingstudentimpressionsacrossthe1through 7 student outcomes, but not necessarily focusing on any particular outcome. The data is gathered during a one-hour meeting in an informal setting and is communicated likewise to the faculty duringanoralbriefingsession.AttimestheBOAmayreportinwritingregardingselectitems, but that decision is left to them.

RELATED ITEM LEVEL 2

## Results (for Critical Thinking)

**Results:**

**Critical Thinking:** Students taking CHE 3111 (Heat Transfer) and CHE 3121 (Fluid Mechanics) during the 2019-20 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. CAT results have not been received as of yet for these courses in the 2019-2020 reporting period. 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 contains questions directly related to the attainment of Program Goals. Written comments were also collected.

**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.

At the BOA meeting in November 2019, updates were provided from a sub-committee previously appointed to develop a formal process for selecting the chair of the Board as well as the duration of the appointment. Updates were also provided on the department's process aligned with its ABET accreditation. In addition, the Board received an update from the Development Officer and had conversations with the university President and Dean of the College of Engineering. Interactions with faculty and staff in the department as well as undergraduate and graduate students were also a major aspect of the meeting.

**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 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, 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. 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 3121 (Transfer Science II: Fluid Mechanics)**

**Target rubric value:** 70%

**Overall Class Average Performance:** 79.2% (This percentage indicates that the class average performance was above target rubric.)

While the course instructor noted slightly decreased levels of performance with regards to previous years, it was also noted that these minor variations in performance were not notable at this time due to the transition of assessment within the curriculum.

**CHE 4210 (Chemical Reaction Engineering)**

**Target rubric value:** 70%

**Overall Class Average Performance:** 68.9% (This percentage indicates that the class average performance was just below target rubric.)

The course instructor noted in the previous review cycle that there existed student deficiencies with respect to designing, executing and reporting on laboratory experiments as well as with student ability to execute a literature review. The course instructor has developed and integrated new laboratory experiences for the students in which she addresses these issues explicitly. While communication in student reports was improved for this reporting period, the course instructor noted that students struggled with drawing meaningful conclusions from laboratory data. In order to address the noted concerns, the course instructor indicated a need for further design and implementation 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:** 85.9% (This percentage indicates that the class average performance was above target rubric.)

The course instructor noted that the lowest average performance for the course was related to clear description and professional use of approach, procedures and methods as appropriate to the activities of the course. Therefore, the course instructor noted that specific instruction early in the semester on this topic may be warranted.

**CHE 4410 (Chemical Engineering Process Design I)**

**Target rubric value:** 70%

**Overall Class Average Performance:** 83.3% (This percentage indicates that the class average performance was above target rubric.)

The course instructor noted that students did notably better this term regarding overall preparedness for design, and preliminarily attributed this high-level of preparedness to changes recently made to CHE 3121 Transfer Science II, which now incorporates elements of a one-dimensional, i.e. limited, design activity which requires students to identify and design for a targeted need which can be addressed by some form of fluidics design.

**CHE 4420 (Chemical Engineering Process Design II)**

**Target rubric value:** 70%

**Overall Class Average Performance:** 91.8% (This percentage indicates that the class average performance was above target rubric.)

The course instructor noted that students did notably better this term overall, achieving very high marks overall, i.e. high course averages against all student outcomes, and with very few students falling below individual rubric. These minor variations in performance were indicated as “not notable at this time”, given that the scoring rubrics are new to the faculty and need to be used for at least one or two more terms before significant interpretations can be made.

**CHE 4540 (Process Dynamics and Controls)**

**Target rubric value:** 70%

**Overall Class Average Performance on Selected Program Outcomes: 82.12%** (This percentage indicates that the class average performance was above target rubric.)

The course instructor noted that the students needed more input on various stages of their project. This concern was noted due to practicing social distancing in the second half of the semester, which is when the project for the course started. While primarily attributed to an abnormal semester in the midst of a pandemic, the course instructor noted that more meetings with the teams, either by the instructor or the TA, were necessary in future semesters.

**Attachments:**

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. 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. The FE exam is no longer used as an assessment tool in our 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.

**Attachments:**

RELATED ITEM LEVEL 3

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

**Program Changes and Actions due to Results:**

Changes to the CHE 3730 (CHE Operations) course have been implemented in which the course was transitioned from a 3 credit to a 2 credit hour course. The additional hour was distributed to the CHE 4240 (CHE Capstone Lab) course to help establish more connection of statistical analysis to unit operations and based on feedback from the BOA and from the Chair Debriefings as mentioned in last year's report.

**Link to Assessment:**

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