Institutional Effectiveness
2024-2025

Program: Chemical Engineering BSCHE
College and Department: College of Engineering, Chemical Engineering
Contact: Dr. Kevin West and Dr. Robby Sanders
Mission:

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:

Mission: 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.

Vision: 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.

Attach Curriculum Map (Educational Programs Only):
Attached Files: See Appendix 1

PO1: Real-World Problem Solvers

Define Outcome:
The graduates of our program will obtain positions such as plant process engineer, design engineer, group leader, production engineer, sales engineer.

Assessment Methods:
Student learning outcomes 1-7 are mapped to Program Goal 1, so the same assessment methods communicated for the SLO's apply here. In addition, LinkedIn profiles of alumni often contain position titles.

Criteria for Success (Thresholds for Assessment Methods):

1. Student learning outcomes are met.
2. Position titles are aligned with those of real-world problem solvers.

Link to 'Tech Tomorrow' Strategic Plan:
1.A Experiential Learning,4.E Economic Development

Results and Analysis:
Please refer to the results shared for student learning outcomes 1-7.

Also, regarding positions held by CHE graduates, an exploration of job titles continues to indicate good alignment with real-world problem solving.

Use of Results to Improve Outcomes:
No actions are currently planned.

PO2: Critical Thinkers

Define Outcome:
The graduates of our program will demonstrate that they consistently make informed decisions through a process wherein they utilize critical thinking skills.

Assessment Methods:
Student learning outcomes 1, 2, 4, 6, and 7 are mapped to Program Goal 2, so the same assessment methods communicated for the SLO's apply here. In addition, the California Critical Thinking Skills Test (CCTST) is used as the exit exam at the university.

Criteria for Success (Thresholds for Assessment Methods):

1. Student learning outcomes are met.

Link to 'Tech Tomorrow' Strategic Plan:
3.A Efficiency and Effectiveness

Results and Analysis:
Results (for Critical Thinking) --Program Goal 2 and Student Learning Outcomes 1, 2, and 6: For 2024-2025, 46 students in CHE took the California Critical Thinking Skills Test (CCTST) with a mean score of 81.4. This score is slightly higher than those from the previous four years (2020-2021: 79.3, n = 56 | 2021-2022: 78.7, n = 31 | 2022-2023: 80.7, n=26 | 2023-2024: 78.9, n=34).

Source: https://www.tntech.edu/iare/assessment/criticalthinking.php

In addition, per results from the "Co-Op Employer Survey" discussed in the "Results: Other" section, CHE co-ops continue to demonstrate a high level of competency in critical thinking (Note: A score of 4 or 5 indicates that the employer agrees or strongly agrees, respectively, with the following statement, "Student can identify and respond to needs based upon an understanding of situational context and logistical analysis of relevant information."). All seven CHE students employed as a co-op in the Summer 2024 and/or Fall 2024 semester(s) received a score (as related to critical thinking) of 4 or 5 from their supervisor.

Use of Results to Improve Outcomes:
Chemical engineering students continue to perform well on the CCTST exam, and employers seem pleased with the demonstrated critical thinking skills of our co-op students. No actions are currently planned in specific response to these outcomes.

PO3: Formal Education

Define Outcome:
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.

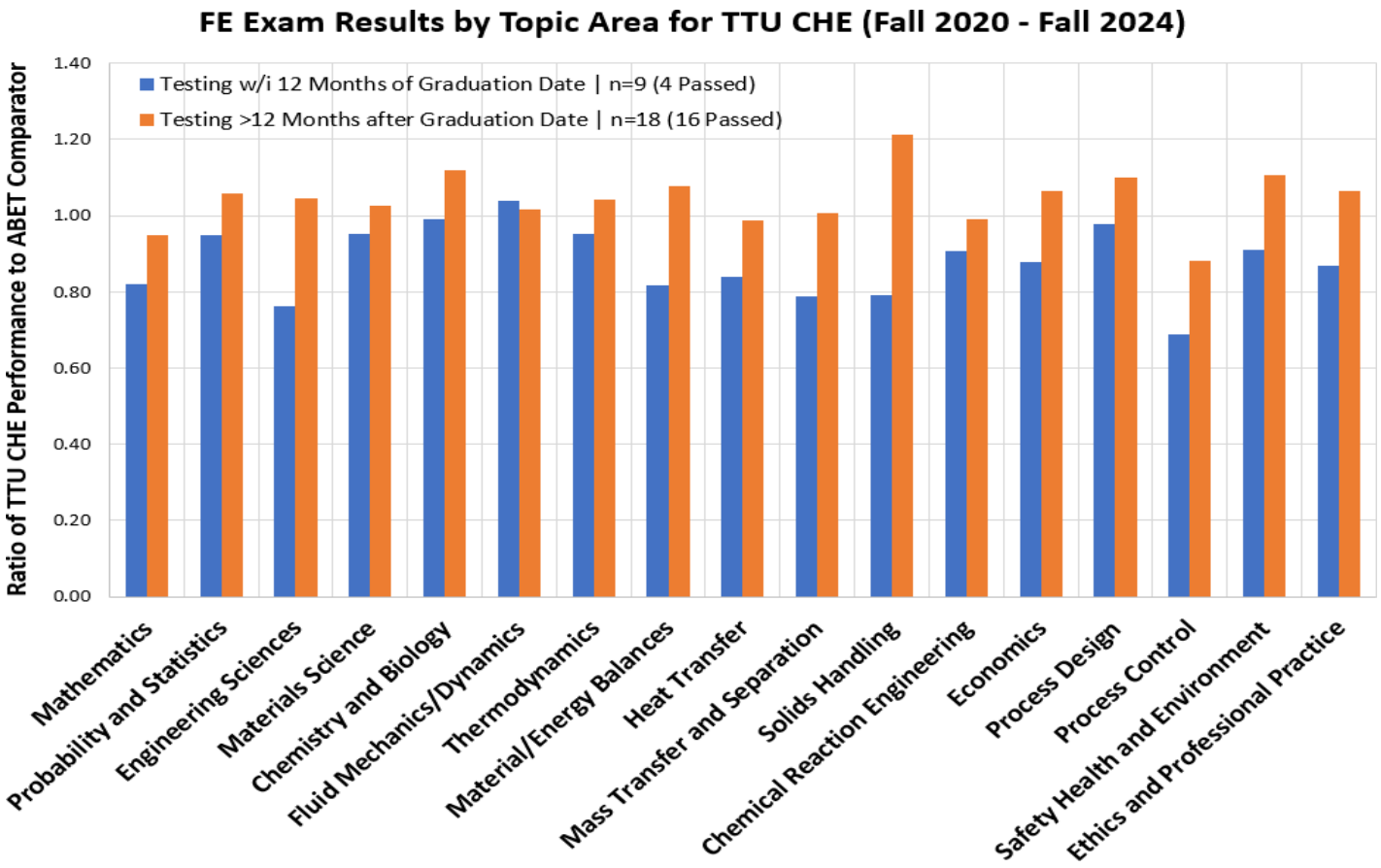
Assessment Methods:
Student learning outcome 7 is mapped to Program Goal 3, so the same assessment methods communicated for this SLO applies here. In addition, completion of the FE and related professional exams provide indications of a commitment to lifelong learning.

Criteria for Success (Thresholds for Assessment Methods):

1. Student learning outcome is met.
2. Students/graduates complete the FE (or related) exam.

Link to 'Tech Tomorrow' Strategic Plan:
1.A Experiential Learning

Results and Analysis:
Completion of the "Fundamentals of Engineering Exam" (the FE Exam) generally after the BS degree is conferred is one indicator of students continuing their education. In official reports that are generally received bi-annually, two designations are made: 1) those who have completed the exam within 12 months of graduation and 2) those completing the exam >12 after graduation. As recommended in the previous year's report, a detailed analysis of CHE student performance on each of the tested topical areas on the FE Exam has been completed with results (for the time frame from ~Fall 2020 to ~Fall 2024) shown in the figure below:



The data are normalized to *performance by the ABET Comparator* with a score of 1 indicating that our students perform at the same level as all students in the ABET Comparator. Based on this analysis, the average performance of our students completing the FE Exam within 12 months of graduation (n=9, four of whom passed) is less than that of students in the ABET Comparator but in general significantly higher among the 18 students (16 of whom passed) who completed the FE Exam >12 months from graduation.

Use of Results to Improve Outcomes:

As completion of the FE Exam is not a requirement in our program, most of our students/graduates do not choose to take the exam. As such, the sample size corresponding to the data presented here for CHE is somewhat small. Even still, the high pass rate of graduates taking the exam >12 months after graduation and passing the exam is encouraging. Particularly in topical areas that our students are performing at or below the ABET Comparator, strategies will be pursued to address this discrepancy. For example, practice problems associated with the FE Exam will be assigned as homework in the department's CHE 4050: Mass Transfer course.

PO4: Working at the Frontiers in CHE

Define Outcome:
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.

Assessment Methods:
Student learning outcomes 1-7 are mapped to Program Goal 4, so the same assessment methods communicated for the SLO's apply here.

Criteria for Success (Thresholds for Assessment Methods):

1. Student learning outcomes are met.

Link to 'Tech Tomorrow' Strategic Plan:
4.E Economic Development

Results and Analysis:
Please refer to the results shared for student learning outcomes 1-7.

Use of Results to Improve Outcomes:
After assessment of student interest and with consideration of anticipated growth in the chemical manufacturing industry, a new concentration in the area of "Chemical Process Manufacturing" has recently been approved to begin in the department in Fall 2025 semester. This new concentration incorporates the following additional courses that build on the program's core:

- CHE 3340: Industry 4.0
- CHE 4400: Engineering Safety
- CHE 4560: Agile Manufacturing
- MET 4650: Lean Six Sigma

In addition, two elective courses (chosen from a listing of aligned courses) are also required, and students can readily integrate a Minor in Chemistry by choosing the Quantitative Analysis and Instrumental Analysis courses from the listing.

SLO1: Formulate and Solve

Define Outcome:

Formulate and Solve - an ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives
    a. (Likert≤3)
2. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 4060/4061 Kinetics (≤ 70%) *
    b. CHE 4540 Controls (≤ 70%)
3. Co-Op Employer Assessments: (Semi or annually). The Department uses a survey report directly completed by the students' supervisor at the co-op site to learn about important student competencies. The questionnaire requires responses related to each of the 1 through 7 student outcomes.
    a. (Likert≤3)

*Note: Effective with the Fall 2022 semester, the CHE 4210 course with lab (4 credits total) was divided into a lecture section (3 credits) and a lab section (1 credit) which are numbered CHE 4060 and CHE 4061, respectively.

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. Course-Level Assessments
    a. Course-Level Assessments are completed for select courses every term in which they are offered
        i. >60% (>70%)
3. Co-Op Employer Assessments

a. 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.
    i. Likert ≥3/5

Link to 'Tech Tomorrow' Strategic Plan:

2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO1: FORMULATE & SOLVE – an ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3) ^		**4.2 (n=31)**	**4.5 (n=31)**	**4.3 (n=45)**
Course-Level Assessments	CHE 4060/61 Kinetics (Goal ≥ 70%)	*	**92%**	**82%**
	CHE 4540 Controls (Goal ≥ 70%)			-
Co-Op Employer Assessments (Goal ≥ 3) #		**4.2**	**4.4**	**4.8**

Notes:

^For the Senior Survey, among other items, students indicate their level of satisfaction on the achievement of each of the seven SLO's choosing one from the following options: Excellent, Very Good, Average, Less than Average, and Poor. Scores of 5, 4, 3, 2, and 1 are assigned to each of these, respectively. The goal is that no individual score is less than 3 which corresponds to Average. There were 45 student responses regarding this outcome for 2024-2025, and only one was below rubric (i.e., the response indicated "Less than Average"). There were 31 responses for this student outcome for both 2022-2023 and 2023-2024, and again only one (in 2024) was below rubric. The values reported in the

table represents a weighted average that was obtained by multiplying the number of responses at each level by the numeric equivalent (5, 4, 3, 2, 1), summing these products, and then dividing by the total number of responses.

[#]None of the employer scores of student's co-op performance as related to this SLO were below 3, and all scores for 2024-2025 were 4 or 5. The values reported in the table correspond to the average score received from all of the assessments.

Results for the CHE 4060/4061 course/lab are largely associated with student performance on exams which include conceptual questions and problems focused on the development of material balance equations, interpretation of concentration profiles associated with particular reaction schema, analysis of stoichiometry, and determination of reaction rate constants. In addition, simple calculations or characterizations related to different reactor types were required. A detailed analysis is available in the Course Level Assessment and Curriculum Improvement Reports (CLACIR's) that are on-file in the department.

*Results are not available.

[-]Analysis is in progress.

The green shading represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:

Student feedback on the senior survey continues to be generally positive with affirmations of program quality/impact and comments provided that point to opportunities for improvement which will be discussed in the department. Per the CLACIR's for the CHE 4060/4061 course/lab, feedback to the instructors "has been overwhelmingly positive," and the integrated lecture/lab approach continues to provide a robust environment for student-centered learning. The extensive efforts that have been pursued to formalize and better articulate the lab-related activities in courses throughout the curriculum is providing consistent opportunities for hands-on learning activities which will continue to be expanded and improved to support students' ability to formulate and solve complex engineering problems.

SLO2: Design for Need, Safety, Global and Social Factors

Define Outcome:

Design for Need, Safety, Global and Social Factors - an ability to apply engineering design to produce solutions that meet specific needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives
    a. (Likert≤3)
2. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 3550/3551 Trans. Sci. II (≤ 70%) **
    b. CHE 4410 Design I (≤ 70%)
    c. CHE 4420 Design II (≤ 70%)
3. Co-Op Employer Assessments: (Semi or annually). The Department uses a survey report directly completed by the students' supervisor at the co-op site to learn about important student competencies. The questionnaire requires responses related to each of the 1 through 7 student outcomes.
    a. (Likert≤3)

**Note: Effective with the Spring 2022 semester, the CHE 3121 course with lab (4 credits total) was divided into a lecture section (3 credits) and a lab section (1 credit) which are numbered CHE 3550 and CHE 3551, respectively.

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. Course-Level Assessments

a. Course-Level Assessments are completed for select courses every term in which they are offered
    i. >60% (>70%)

3. Co-Op Employer Assessments
    a. 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.
        i. Likert ≥3/5

Link to 'Tech Tomorrow' Strategic Plan:

2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO2: DESIGN for NEED, SAFETY, GLOBAL & SOCIAL FACTORS – an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3) ^		**4.1 (n=31)**	**4.4 (n=31)**	**4.2 (n=45)**
Course-Level Assessments	CHE 3550/51 TS II (Goal ≥ 70%)	**73%**	**97%**	+
	CHE 4410 Design I (Goal ≥ 70%)	**85%**		-
	CHE 4420 Design II (Goal ≥ 70%)	**89%**		-
Co-Op Employer Assessments (Goal ≥ 3) #		**4.3**	**4.4**	**4.8**

Notes:

^Details regarding how values are calculated from the Senior Survey (and reported on for this SLO) are provided under the table in the Results: SLO1 Section. Among the 107 responses provided regarding SLO2 (during the three years shown), only one scored this item below rubric.

#None of the employer scores of student's co-op performance as related to this SLO were below 3, and all scores for 2024-2025 were 4 or 5. The values reported in the table correspond to the average score received from all of the assessments.

+As detailed in prior year's reports, the quantitative results reported here for CHE 3550/51 are based on student performance in the CHE 3551 labs. These efforts which continued for Spring 2025 involve the use of heat exchanger demonstration units, "Desktop Learning Modules," and viscometers which continue to be significantly leveraged in the fluids labs with direct connection to design concepts. In addition, team-based projects continue to be pursued in the CHE 3550 course with this year's teams working on projects with focus on such topics as pipes and pipe fittings, mixing tanks, velocity-measuring devices, etc.). While students are not assessed directly against specific design criteria, the teams explore existing technologies with considerations of costs, societal and environmental impact, safety, and other factors. Per details provided in the CLACIR's and instructor notes, performance on these projects continues to be excellent.

-Analysis is in progress.

The green shading represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:

Worksheets that have been developed during the last two years continue to be refined and leveraged to support lab-based activities (across the curriculum), many of which leverage engineering equipment, knowledge of which supports an understanding of design.

SLO3: Communicate

Define Outcome:

Communicate - an ability to communicate effectively with a range of audiences

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives
    a. (Likert≤3)
2. External Review of Senior (Capstone) Design Projects (Annually). External evaluators are invited to assess the quality of 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.
    a. (team average ≤ 70%)
3. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 3550/3551 Trans. Sci. II (≤ 70%) **
    b. CHE 4060/4061 Kinetics (≤ 70%) *
    c. CHE 4240 Capstone Lab (≤ 70%)
    d. CHE 4410 Design I (≤ 70%)
    e. CHE 4420 Design II (≤ 70%)
    f. CHE 4540 Controls (≤ 70%)
4. Co-Op Employer Assessments: (Semi or annually). The Department uses a survey report directly completed by the students' supervisor at the co-op site to learn about important student competencies. The questionnaire requires responses related to each of the 1 through 7 student outcomes.
    a. (Likert≤3)

**Note: Effective with the Spring 2022 semester, the CHE 3121 course with lab (4 credits total) was divided into a lecture section (3 credits) and a lab section (1 credit) which are numbered CHE 3550 and CHE 3551, respectively. *Note: Effective with the Fall 2022 semester, the CHE 4210 course with lab (4 credits total) was divided into a lecture section (3 credits) and a lab section (1 credit) which are numbered CHE 4060 and CHE 4061, respectively.

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. External Review of Senior (Capstone) Design Projects
    a. Design II projects are externally assessed in the Spring of each year.
        i. >60% (>70%)
3. Course-Level Assessments
    a. Course-Level Assessments are completed for select courses every term in which they are offered
        i. >60% (>70%)
4. Co-Op Employer Assessments
    a. 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.
        i. Likert ≥3/5

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning,2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO3: COMMUNICATE – an ability to communicate effectively with a range of audiences

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3) ^		**4.3**	**4.5**	**4.5**
External Assessment of Capstone Labs (team average ≥ 70%)			+	-
Course-Level Assessments	CHE 3550/51 TS II (Goal ≥ 70%)	**93%**	**97%**	+

	CHE 4060/61 Kinetic (Goal ≥ 70%)	*	**94%**	**97%**
	CHE 4250 Capstone Lab (Goal ≥ 70%)	+	+	-
	CHE 4410 Design I (Goal ≥ 70%)	**90%**		-
	CHE 4420 Design II (Goal ≥ 70%)	**89%**		-
	CHE 4540 Controls (Goal ≥ 70%)			-
Co-Op Employer Assessments (Goal ≥ 3) [#]		**4.3**	**4.4**	**4.5**

Notes:

[^]Details regarding how values are calculated from the Senior Survey (and reported on for this SLO) are provided under the table in the Results: SLO1 Section. Among the 106 responses provided regarding SLO3 (during the three years shown), only two scored this item below rubric.

[#]None of the employer scores of students' co-op performance as related to communication were below 3, and all scores for 2024-2025 were 4 or 5. The values reported in the table correspond to the average score received from all the assessments.

[+]The hands-on, lab-based activities in CHE 3551 and in CHE 4061 as reported in the previous years' reports continue to be pursued with multiple opportunities for students to communicate with each other and their instructors/TAs on experiments. The observed overall student performance was excellent. Likewise, team-based projects continue to be pursued in the CHE 3550 course with this year's teams working on projects with focus on such topics as pipes and pipe fittings, mixing tanks, velocity-measuring devices, etc. Student teams pursue in-depth investigations of fluids-related topics and complete two presentations during the semester with instructor-provided comments indicating overall positive performance in communication.

Regarding capstone lab from Spring 2025, multiple "judges" (comprised primarily of faculty and alumni) interacted with capstone teams at their end-of-semester showcase event. Instead of working on externally sponsored capstone projects as was originally envisioned, the department implemented an approach modeled after the AICHE Cube Competition. Specifically, teams were to focus on a particular challenge and develop a process to address the challenge. As in years past, the teams were to design, setup, and complete experiments (with follow-up analysis of data) with a finite amount of monetary resources, but in addition a constraint was imposed that the team's experimental setup needed to fit into a 1-foot cube in alignment with rules of the AICHE Cube Competition. Ultimately, four topics (listed below) were identified during the Fall semester, and four teams of three or four students were identified to pursue a given project in the Spring semester based on priority ranking for preferred projects provided by students:

- Cesium Extraction from Hypothetical Spent Nuclear Fuel
- NaCl Recrystallization from a Reject Stream
- Capture/Sequestration of CO2 from an Effluent
- Pet Dialysis and Enzymatic Breakdown of Urea

Overall, students performed very well in communicating project details at the showcase.

*Results are not available.

-Analysis is in progress.

Yellow shading represents a “watch, possibly act” situation while green represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:
A rubric was used to assist in evaluation of student performance on the capstone projects.

Per the CLACIR for the CHE 4060/61 course, "This structure [of separate instructors for lecture and lab] provided several advantages, such as allowing specialized focus on lecture-based content and hands-on lab instruction, better coordination of workload between the two components, and an enhanced ability for instructors to tailor their expertise to their respective areas."

SLO4: Ethics

Define Outcome:

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.

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives
    a. (Likert≤3)
2. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 4420 Design II (≤ 70%)
    b. CHE 4540 Controls (≤ 70%)
3. Co-Op Employer Assessments: (Semi or annually). The Department uses a survey report directly completed by the students' supervisor at the co-op site to learn about important student competencies. The questionnaire requires responses related to each of the 1 through 7 student outcomes.
    a. (Likert≤3)

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. Course-Level Assessments
    a. Course-Level Assessments are completed for select courses every term in which they are offered
        i. >60% (>70%)
3. Co-Op Employer Assessments

a. 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.
    i. Likert ≥3/5

Link to 'Tech Tomorrow' Strategic Plan:

2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO4: 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

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3) ^		**4.3 (n=31)**	**4.5 (n=31)**	**4.4 (n=45)**
Course-Level Assessments	CHE 4420 Design II (Goal ≥ 70%)	**92%**		-
	CHE 4540 Controls (Goal ≥ 70%)			-
Co-Op Employer Assessments (Goal ≥ 3) #		**4.3**	**4.5**	**4.8**

Notes:

^Details regarding how values are calculated from the Senior Survey (and reported on for this SLO) are provided under the table in the Results: SLO1 Section. Among the 107 responses provided regarding SLO4 (during the three years shown), only one scored this item below rubric.

#None of the employer scores of students' co-op performance as related to ethics were below 3, and all scores for 2024-2025 were 4 or 5. The values reported in the table correspond to the average score received from all of the assessments.

-Analysis is in progress.

The green shading represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:
No actions are currently planned.

SLO5: Teams

Define Outcome:

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.

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives
    a. (Likert≤3)
2. External Review of Senior (Capstone) Design Projects (Annually). External evaluators are invited to assess the quality of 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.
    a. (team average ≤ 70%)
3. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 4240 Capstone Lab (≤ 70%)
    b. CHE 4420 Design II (≤ 70%)
4. Co-Op Employer Assessments: (Semi or annually). The Department uses a survey report directly completed by the students' supervisor at the co-op site to learn about important student competencies. The questionnaire requires responses related to each of the 1 through 7 student outcomes.
    a. (Likert≤3)

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. External Review of Senior (Capstone) Design Projects

a. Design II projects are externally assessed in the Spring of each year.
    i. >60% (>70%)

3. Course-Level Assessments
    a. Course-Level Assessments are completed for select courses every term in which they are offered
        i. >60% (>70%)
4. Co-Op Employer Assessments
    a. 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.
        i. Likert ≥3/5

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning,2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO5: 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

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3)^		**4.3**	**4.6**	**4.5**
External Assessment of Capstone Labs (team average ≥ 70%)			+	-
Course-Level Assessments	CHE 4250 Capstone Lab (Goal ≥ 70%)		+	-
	CHE 4420 Design II (Goal ≥ 70%)	**93%**		-
Co-Op Employer Assessments (Goal ≥ 3)#		**4.5**	**4.7**	**4.8**

Notes:

[^]Details regarding how values are calculated from the Senior Survey (and reported on for this SLO) are provided under the table in the Results: SLO1 Section. Among the 107 responses provided regarding SLO5 (during the three years shown), only one scored this item below rubric.

[#]None of the employer scores of student's co-op performance as related to teamwork were below 3, and all scores for 2024-2025 were 4 or 5. The values reported in the table correspond to the average score received from all of the assessments.

[+]Students have significant opportunities to work in teams on projects throughout the curriculum. Notes from the other courses are provided in prior years' reports.

[-]Analysis is in progress.

Yellow shading represents a “watch, possibly act” situation while green represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:

No actions are currently planned.

SLO6: Experiment, Analyze, and Interpret

Define Outcome:

Experiment, Analyze, and Interpret - an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives
    a. (Likert≤3)
2. External Review of Senior (Capstone) Design Projects (Annually). External evaluators are invited to assess the quality of 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.
    a. (team average ≤ 70%)
3. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 4060/4061 Kinetics (≤ 70%) *
    b. CHE 4240 Capstone Lab (≤ 70%)

*Note: Effective with the Fall 2022 semester, the CHE 4210 course with lab (4 credits total) was divided into a lecture section (3 credits) and a lab section (1 credit) which are numbered CHE 4060 and CHE 4061, respectively.

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. External Review of Senior (Capstone) Design Projects
    a. Design II projects are externally assessed in the Spring of each year.

i. >60% (>70%)

3. Course-Level Assessments
   a. Course-Level Assessments are completed for select courses every term in which they are offered
      i. >60% (>70%)

Link to 'Tech Tomorrow' Strategic Plan:

1.A Experiential Learning,2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO6: EXPERIMENT, ANALYZE & INTERPRET – an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3)^		**4.1**	**4.6**	**4.5**
External Assessment of Capstone Labs (team average ≥ 70%)			+	-
Course-Level Assessments	CHE 4060/61 Kinetics (Goal ≥ 70%)	*	**92%**	**90%**
	CHE 4250 Capstone Lab (Goal ≥ 70%)		+	-

Notes:

^Details regarding how values are calculated from the Senior Survey (and reported on for this SLO) are provided under the table in the Results: SLO1 Section. Among the 107 responses provided regarding SLO6 (during the three years shown), only one scored this item below rubric.

[+]Students have significant opportunities to work on experiments in several CHE courses and in particular the many lab-based courses that are a formal part of the curriculum including: CHE 3051, CHE 3511, CHE 3551, CHE 4051, CHE 4061, and CHE 4250. In addition, courses such as CHE 2020, CHE 3050, CHE 3550, and CHE 4420 have extensive team-based activities as do the CHE 3140 and CHE 4661 courses that are required for students in the biomolecular engineering concentration.

The "New Seeking Improvement Item" that was communicated in last year's report involved increasing opportunities for hands-on learning. Significant advancements have been made regarding this, particularly through the addition of new lab-focused personnel and the continued refinement/development of lab activity worksheets and SOP's as well as implementation of a better-articulated schedule to guide activities. The department's senior survey continues to provide a primary source for informing the improvements, and from the most recent report, 23 students scored their satisfaction with SLO6 as being Excellent; 20 scored it as Very Good, and two students scored it as Average ultimately leading to a weighted score of 4.47. While this number is slightly below the 4.61 reported last year, it is higher than the 4.13 from 2023 (both years of which had 31 students responding compared to 46 this year). Students continue to express interest in more hands-on learning experiences (and simulation-focused efforts with software), and efforts will continue to be pursued in support of this.

Notes on the items marked with "+" are provided in prior years' reports.

*Results are not available.

[-]Analysis is in progress.

Yellow shading represents a “watch, possibly act” situation while green represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:

The integration of new lab-focused personnel has been tremendously valuable in supporting a wide range of student-centered lab activities in the department including the implementation of the department's current strategy for providing hands-on learning experiences, the development of new SOP's, the improvement of existing processes related to lab safety and maintenance of chemical inventories, increasing access to equipment, assisting in the set-up of new lab spaces, and performing equipment maintenance, among many other activities.

SLO7: Knowledge Acquisition and Application

Define Outcome:

Knowledge Acquisition - an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Assessment Methods:

1. 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 SLOs. In this way, feedback is gathered from the student sector of our constituency on both student outcomes and program educational objectives.
    a. (Likert≤3)
2. Course-Level Assessments: (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 the current "Articulation Matrix" 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.
    a. CHE 3550/3551 Trans. Sci. II (≤ 70%) **
    b. CHE 4410 Design I (≤ 70%)
3. Co-Op Employer Assessments: (Semi or annually). The Department uses a survey report directly completed by the students' supervisor at the co-op site to learn about important student competencies. The questionnaire requires responses related to each of the 1 through 7 student outcomes.
    a. (Likert≤3)

**Note: Effective with the Spring 2022 semester, the CHE 3121 course with lab (4 credits total) was divided into a lecture section (3 credits) and a lab section (1 credit) which are numbered CHE 3550 and CHE 3551, respectively.

Criteria for Success (Thresholds for Assessment Methods):

1. Senior Survey
    a. A population of seniors is surveyed once every third year.
        i. Likert ≥3/5
2. Course-Level Assessments
    a. Course-Level Assessments are completed for select courses every term in which they are offered
        i. >60% (>70%)
3. Co-Op Employer Assessments

a. 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.
    i. Likert ≥3/5

Link to 'Tech Tomorrow' Strategic Plan:

2.A Technology Infused Programs,3.A Efficiency and Effectiveness

Results and Analysis:

SLO7: KNOWLEDGE ACQUISTION & APPLICATION – an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Assessment Process (threshold Student Outcome attainment level)		**2022-2023**	**2023-2024**	**2024-2025**
Senior Survey (Goal ≥ 3) ^		**4.2**	**4.5**	**4.5**
Course-Level Assessments	CHE 3550/51 TS II (Goal ≥ 70%)	**76%**	**97%**	+
		78%	**85%**	**92%**
	CHE 4410 Design I (Goal ≥ 70%)	**78%**		
Co-Op Employer Assessments (Goal ≥ 3) #		**4.5**	**4.6**	**4.6**

Notes:

^Details regarding how values are calculated from the Senior Survey (and reported on for this SLO) are provided under the table in the Results: SLO1 Section. Among the 107 responses provided regarding SLO7 (during the three years shown), only two scored this item below rubric.

[#]None of the employer scores of student's co-op performance as related to this SLO were below 3, and all scores for 2024-2025 were 4 or 5. The values reported in the table correspond to the average score received from all of the assessments.

+The bottom numbers for CHE 3550/51 correspond to the average exam scores from three exams in each Spring semester of the three indicated years. This average is above the threshold of 70%. Looking at students scoring below this threshold, the percentage of exams completed with a score less than this threshold has been decreasing during this timeframe going from 24% in 2023 to 13% in 2024 to 10% in 2025. In the context of a holistic strategy, performance on these exams is one way that students demonstrate their ability "to acquire and apply new knowledge" as indicated by ABET for this SLO.

[-]Analysis is in progress.

The green shading represents that the value meets threshold (i.e., is at or above the goal).

Use of Results to Improve Outcomes:
No actions are currently planned.

Summative Evaluation:

Chemical engineering students continue to perform well individually and in team-based settings, showcasing cumulative knowledge gains that have prepared them for successfully navigating senior design and capstone laboratory courses. The former requires significant understanding of prior course content, acquisition of new skills in chemical process modeling, and understanding of how to conduct safety analyses. The latter involves the ability to setup and safely execute hands-on lab experiments and to collect and analyze data. In addition, CHE students again demonstrated excellent performance on the California Critical Thinking Skills Test which serves as the university's senior exit exam, and CHE co-ops continue to earn strong endorsements from their industry supervisors. The high pass rate of graduates from the program on the FE Exam (and the particularly impressive performance in fluids-related topics) speaks well to students' skillsets upon graduation and their commitment to continuing their learning. The hands-on lab experiences seem to be making a very positive impact and based on feedback shared during the department's senior exit survey, the efforts to further integrate and expand hands-on learning experiences should be actively pursued.

Assessment Plan Changes:

The department is actively engaged in the development of new rubrics to guide assessment of SLO's in multiple CHE courses including all of those described in this report. Template rubrics are currently available, and these are being modified to facilitate assessment of key performance indicators (KPI's) identified by the faculty and associated with the SLO's. For the process, particular assignments/activities will be identified by the instructors for each of these courses, and these items communicated for input to a small team of faculty assigned by the department Chair. The instructor will conduct the course as planned and grade work as normally done. The graded assignments will be saved (scanned copies as necessary) and subsequently assessed against the rubric by the team who will categorize each student's work as related to the KPI as being Highly Proficient, Proficient, or Not Proficient. A pilot implementation of the approach in the junior-level CHE 3510-Separations and Solution Thermodynamics course (Spring 2025) and with a particular emphasis on SLO1 resulted in the following outcomes:

- 90.4% of students in the class performed at or above a proficient level which was designated as being >= 70% correct responses on pre-identified questions on quizzes and exams while 9.6% scored below a proficient level.

This approach will enable the use of the same rubrics across multiple courses with flexibility provided by which KPI's are emphasized in a given course.

List of Appendices:

Appendix 1: Curriculum Map

Appendix 1: Curriculum Map

Mapping of Student Outcomes and Program Educational Objectives

	Program Educational Objectives			
Student Outcomes	**Real World Problems Solver (RWPS)**	**Critical Thinker (CT)**	**Continue Formal Education (CFE)**	**Work at Frontiers in Chemical Engineering (FChE)**
1 Formulate	X	X		X
2 Design	X	X		X
3 Communicate	X			X
4 Ethics	X	X		X
5 Teams	X			X
6 Experiment	X	X		X
7 Knowledge	X	X	X	X

Articulation Matrix for the period beginning May 2020* for purposes of Course-Level Student Outcomes assessment

Course No.	Description	Required or Elective (R or E)	Mapping to Student Outcomes (SO)						
			1 Formulate & Solve	2 Design for Need, Safety, Global & Societal	3 Communicate	4 Ethics in Global & Societal Context	5 Teams	6 Experiment Analyze & Interpret	7 Knowledge Acquisition
CHE 1010	Intro. to CHE	R							
CHE 1020	CHE Process., Prod. & Ethics	R							
CHE 2015	Chem and Biol Eng. Analysis I	R							
CHE 2020	Chem and Biol Eng. Analysis II	R							
CHE 3010	Thermo of Chem. Proc.	R							
CHE 3050/51	Cond., Rad., Diff. w/Lab	R							
CHE 3735	CHE Operations	R							
CHE 3510/11	CHE Thermodynamics II w/Lab	R							
CHE 4050/51	Diff. & Mass Transfer w/Lab	R							
CHE 3550/51*	**TS II: Fluid Mechanics w/Lab****	**R**		**ABET**	**ABET**				**ABET**
CHE 4060/61*	**Chemical Reaction Engineering w/Lab****	**R**	**ABET**		**ABET**			**ABET**	
CHE 4250	**ChE Capstone Laboratory**	**R**			**ABET**		**ABET**	**ABET**	
CHE 4410	**Process Design I**	**R**		**ABET**	**ABET**				**ABET**
CHE 4420	**Process Design II**	**R**		**ABET**	**ABET**	**ABET**	**ABET**		
CHE 4540	**Process Dynamics & Controls**	**R**	**ABET**		**ABET**	**ABET**			

1	Red	(255, 0, 0)
2	Blue	(0, 112, 192)
3	Orange	(255, 192, 0)
4	Purple	(112, 48, 160)
5	Orange, Accent 6	(247, 150, 70)
6	Yellow	(255, 255, 0)
7	Light Green	(146, 208, 80)

ABET – Assessed Student Outcome for ABET continuous improvement purposes, courses shown in **bold**.

*The table has been updated to reflect changes (effective 2022) in course numbers.

**Assessment of lab-related outcomes is documented in the CLACIR.