

Institutional Effectiveness 2022-2023

Program: Chemical Engineering MS

College and Department: College of Engineering, Department of Chemical Engineering

Contact: 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:

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 Department of Chemical Engineering at Tennessee Tech blends scholarship and research with advanced course work, providing excellent opportunities to graduate students to work towards solving some of the many global challenges faced by society. Our program offers an MS in Chemical Engineering. The relatively small size of the program and friendly campus atmosphere promote close interaction among students and faculty. Research is sponsored by federal agencies (such as NSF) as well as state and private sources among others. Faculty members work closely with colleagues in Electrical and Computer Engineering, Civil and Environmental Engineering, Mechanical Engineering, Chemistry, Biology, and Manufacturing and Engineering Technology at TTU, as well as maintain strong collaboration with TTU's Centers of Excellence and other leading institutions and national laboratories to build a unique and effective environment for graduate student research, learning, and well-rounded training.

These activities are consistent with the TTU mission and vision which are posted at the following website (<https://www.tnitech.edu/about/mission.php>)

Attach Curriculum Map (Educational Programs Only): *See Appendix 1.

PO1: COMPETITIVE GRADUATE STUDENT BODY

Define Outcome:

Develop and maintain a competitive graduate student body in the range of 3-4 graduate students per faculty member with more than half of them pursuing a PhD.

Assessment Methods:

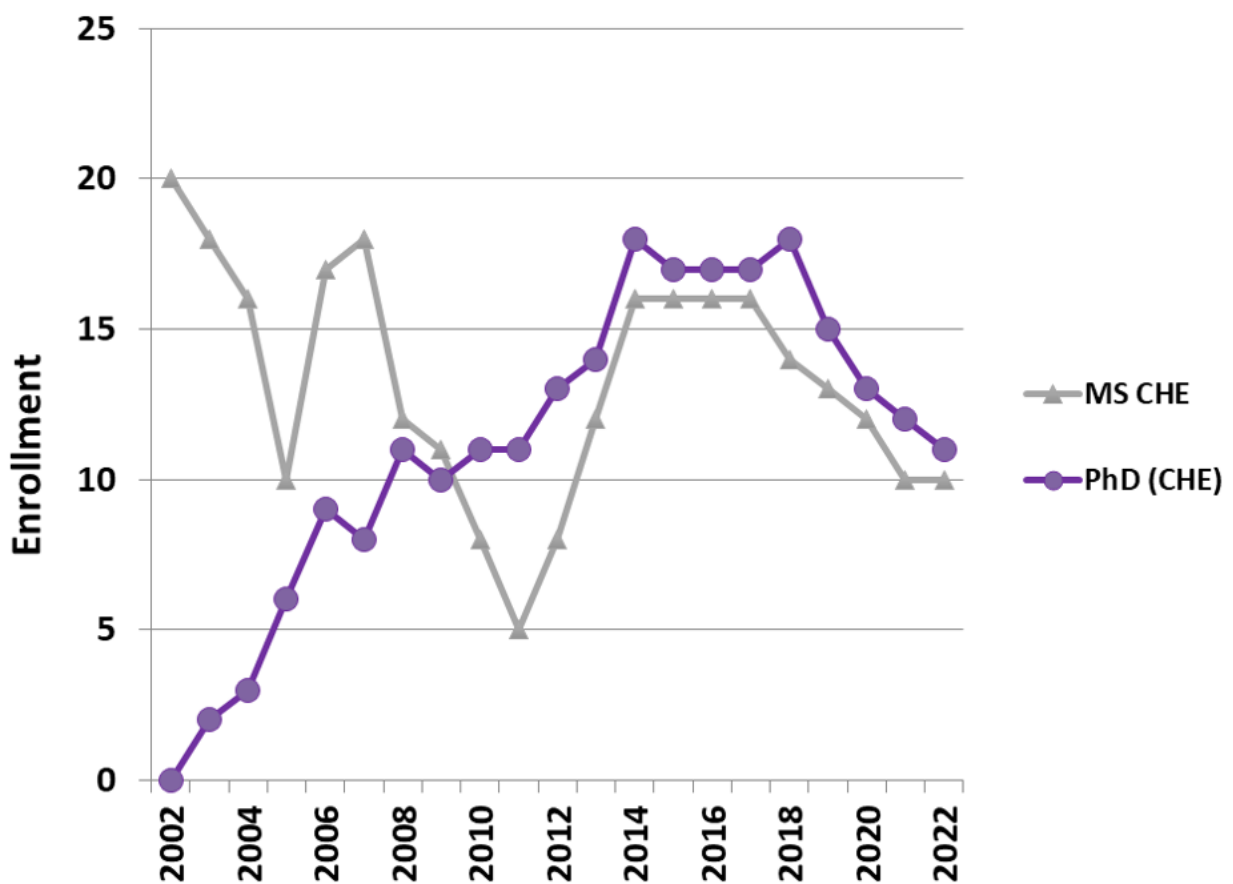
1. CHE Department Graduate Student Admissions and Success Database: These databases are maintained in Excel spreadsheets that are located on a shared drive accessible by the Graduate Program Coordinator and CHE office staff. The department is also leveraging Microsoft Teams for sharing and archiving information related to the program. These spreadsheets include a collection of applicant data (e.g., GRE Scores, BS GPA, TOEFL scores, BS Institution, etc.) for all students applying for admission to the program as well as decisions made by the CHE graduate committee. Upon admission and entry to the graduate program, a separate spreadsheet is used to track each student's entry time, projected graduation date, research advisor, funding status, completion of required courses, and other measures of student success. Data are entered upon entrance of a student into the program and periodically updated.
 - a. Upon entrance of student into program and then periodically throughout the year
2. External and Internal Funding Generated/Obtained: Reports are periodically requested from the TTU Office of Research (or obtained from its website) to provide details on external funding to faculty in the department. In addition, the department maintains a summary of funding status of graduate students in the program and frequently re-assesses this information in efforts to ensure that as many graduate students as possible are supported.
 - a. Annually
3. Graduate Student Enrollment Data: Graduate student enrollment data is maintained in the Student Success Database, and this information is periodically checked using enrollment data provided via the TTU Office of Institutional Research.
 - a. Annually

Criteria for Success (Thresholds for Assessment Methods):

1. CHE Department Graduate Student Admissions and Success Database: Documentation of students admitted and progress towards degree
2. External and Internal Funding Generated/Obtained: Documentation of internal/external grant funding that is used to support faculty research and graduate students
3. Graduate Student Enrollment Data: Maintenance of a graduate student enrollment to faculty ratio of at least 3-4

Results and Analysis:

Fall 2022 census for the MS-CHE program and departmental data for the PhD program, the program shows 48% (10 students) of CHE graduate students are enrolled at the MS level and 52% (11 students) at the PhD level, the latter of which reflects three students who completed their thesis-based MS-CHE degree at TTU and are enrolled in the PhD program and another two students who completed their BS in CHE at TTU and are enrolled in the direct-admit PhD program. Total enrollments in the MS-CHE and PhD (CHE concentration) programs over the last two decades are provided in the figure below which illustrates a cyclical nature of enrollment (particularly in the MS program) that is aligned with a similar pattern for the department's BS program enrollment as well as national trends in CHE enrollment.



Research funding: To complement on-campus sources of graduate student support and to further increase the amount of external funding, several faculty in the department and others across campus prepared a \$3 million grant proposal that was funded (after three previous attempts) in July 2022 by the NSF's National Research Traineeship (NRT) program. Dr. Pedro Arce (Professor of CHE) is the PI of this grant which is expected to run for five years, covering fees and providing stipends to 20 graduate students (12 MS and 8 PhD) with a projected nine of these trainees being graduate students in the CHE department. The efforts will center on the expansion and refinement of the Renaissance Foundry Model to the graduate program and the completion of

research projects at the food-energy-water nexus. Graduate students will be periodically “immersed” in various communities throughout Appalachia and in Native American communities (particularly, Cherokee) where they will work with community stakeholders to identify problems in those communities. Such problems will serve as the basis for research projects completed by students in the program. An extensive evaluation plan will be implemented to inform the decision-making process and ensure that program deliverables are met. Such is expected to guide new and ongoing research efforts in the department and support the department in growing its graduate enrollment.

Use of Results to Improve Outcomes:

The College continues to increase its activities to recruit graduate students, and the department will be actively engaging in recruitment efforts during the 2023-2024 academic year with plans for the Chair to attend the American Institute of Chemical Engineers annual meeting in November of 2023 where a table will be reserved for the department's participation at the Recruitment Fair. Both the department and College continue to increase communications to current students at the university who might be interested in the BS/MS Fast-Track programs. Recruitment of students directly from the department's CHE-BS program to join the CHE graduate program as either an MS student or a direct-admit PhD student has had a very positive impact. Building on a successful first-year recruitment effort, an increased emphasis will be made to recruit chemical engineering students as well as students in other project-related disciplines for participation in the NSF-funded NRT project.

PO2: DIVERSE GRADUATE STUDENT BODY

Define Outcome:

Maintain a diverse graduate student body consisting of domestic and foreign students including minorities and individuals of underrepresented groups.

Assessment Methods:

1. CHE Department Graduate Student Admissions and Success Database: These databases are maintained in Excel spreadsheets that are located on a shared drive accessible by the Graduate Program Coordinator and CHE office staff. The department is also leveraging Microsoft Teams for sharing and archiving information related to the program. These spreadsheets include a collection of applicant data (e.g., GRE Scores, BS GPA, TOEFL scores, BS Institution, etc.) for all students applying for admission to the program as well as decisions made by the CHE graduate committee. Upon admission and entry to the graduate program, a separate spreadsheet is used to track each student's entry time, projected graduation date, research advisor, funding status, completion of required courses, and other measures of student success. Data are entered upon entrance of a student into the program and periodically updated.

- a. Upon entrance of student into program and then periodically throughout the year
2. Diversity of Program Demographics: The diversity and student body demographics are routinely examined with this information being maintained in the Student Success Database.
 - a. Periodically throughout each year
3. Graduate Student Enrollment Data: Graduate student enrollment data is maintained in the Student Success Database, and this information is periodically checked using enrollment data provided via the TTU Office of Institutional Research.
 - a. Annually

Criteria for Success (Thresholds for Assessment Methods):

1. CHE Department Graduate Student Admissions and Success Database: Documentation of students admitted and progress towards degree
2. Diversity of program demographics: Balanced representation from different demographics
3. Graduate Student Enrollment Data: Maintenance of a graduate student enrollment to faculty ratio of at least 3-4

Results and Analysis:

Per the Fall 2022 census, 38% overall (50% at the MS level) of the graduate students are female graduate students, and there are students from the USA, Chile, Hungary, India, Iran, Iraq, Nepal, Nigeria, and Venezuela.

Use of Results to Improve Outcomes:

The College continues to increase its activities to recruit graduate students, and the department will be actively engaging in recruitment efforts during the 2023-2024 academic year with plans for the Chair to attend the American Institute of Chemical Engineers annual meeting in November of 2023 where a table will be reserved for the department's participation at the Recruitment Fair. Both the department and College continue to increase communications to current students at the university who might be interested in the BS/MS Fast-Track programs. Recruitment of students directly from the department's CHE-BS program to join the CHE graduate program as either an MS student or a direct-admit PhD student has had a very positive impact. Building on a successful first-year recruitment effort, an increased emphasis will be made to recruit chemical engineering students as well as students in other project-related disciplines for participation in the NSF-funded NRT project.

PO3: TRAINING IN MODERN CHEMICAL ENGINEERING

Define Outcome:

Provide students with a rigorous, interdisciplinary, and current training through both course work and research projects in relevant areas of modern chemical engineering.

Assessment Methods:

1. CHE Department Graduate Student Admissions and Success Database: These databases are maintained in Excel spreadsheets that are located on a shared drive accessible by the Graduate Program Coordinator and CHE office staff. The department is also leveraging Microsoft Teams for sharing and archiving information related to the program. These spreadsheets include a collection of applicant data (e.g., GRE Scores, BS GPA, TOEFL scores, BS Institution, etc.) for all students applying for admission to the program as well as decisions made by the CHE graduate committee. Upon admission and entry to the graduate program, a separate spreadsheet is used to track each student's entry time, projected graduation date, research advisor, funding status, completion of required courses, and other measures of student success. Data are entered upon entrance of a student into the program and periodically updated.
 - a. Upon entrance of student into program and then periodically throughout the year
2. Periodic Review of Graduate Coursework and Curriculum: Progress made towards completion of required and elective courses is assessed using a variety of approaches. All graduate students are expected to file a program of study not later than the end of the semester in which they will have earned 15 credits towards their degree, and generally they are not allowed to register for subsequent semesters if this is not done. Additionally, a review of graduate courses and the curriculum is periodically completed through meetings between the Department Chair and the Graduate Program Coordinator (currently the same individual) to ensure that courses are offered in a time frame consistent with the program goal for time to graduation. Faculty advisors meet routinely with their advisees to discuss progress in courses and plans for follow-up courses. The Graduate Program Coordinator meets with all new students in the program to discuss courses, the program, and other critical matters. Additions, deletions, and/or changes to the graduate curriculum are first approved via the CHE Graduate Committee and subsequently via the College of Engineering's Graduate Executive Committee (of which the CHE Graduate Program Coordinator is a member), and then the Graduate School Executive Committee.
 - a. Periodically, or as the need arises
3. Thesis Presentation and Defense, Publications, and Other Presentations: All students in the thesis-based MS program are required to complete a thesis presentation and defense. The presentation is completed in a public, seminar-type format at the end of the students' program with the student's thesis committee and others in attendance. Upon completion of the presentation, a question/answer session ensues, and then, with the audience dismissed, the committee discusses the presentation and defense and the student's overall performance in the program and decides whether the student has "passed." As the comprehensive exam is integrated with the thesis defense for MS students, questions may also be asked regarding coursework completed and student knowledge in his/her area. A non-thesis MS degree is also possible for students who desire a more course work intensive graduate degree and for students who are directly admitted to the PHD program. During their program, students are encouraged and

provided the opportunity to be involved in development of manuscripts for submission for peer-reviewed conference proceedings and journal articles and to present at conferences and the on-campus Student Research and Creative Inquiry Day event.

- a. End of the student's program and presentations at Student Research Day

Criteria for Success (Thresholds for Assessment Methods):

1. CHE Department Graduate Student Admissions and Success Database: Documentation of students admitted and progress towards degree.
2. Periodic Review of Graduate Coursework and Curriculum: Courses provide relevant training in advanced chemical engineering concepts. Required courses offered at a frequency to support timely progression towards degree completion. In general, these courses should be offered annually.
3. Thesis Presentation and Defense, Publications, and Other Presentations: Thesis documents are published in the ProQuest Dissertations & Theses database. MS-thesis-based students are encouraged to submit a manuscript to a peer-reviewed journal though such submission is not required for graduation. Non-thesis students submit a "binder" that provides documentation of the work completed for their non-thesis project. All MS students in the department present the outcomes from their thesis-related research or non-thesis project, as applicable.

Results and Analysis:

Students’ programs of study (on file in the CHE office and accessible via Degree Works) reflect comprehensive course work within and beyond CHE. Successful thesis/project defenses, publications, and presentations at research-related events (e.g., conferences, TTU Student Research Day, etc.) reflect relevance of the research efforts to contemporary and more modern problems. The frequency of offering of core (required) and elective graduate courses over the last six years are provided in the two tables immediately below.

Schedule of Core Courses Offered by the CHE Program (Fall 2017- Spring 2023)												
Core Courses	F'17	Sp'18	F'18	Sp'19	F'19	Sp'20	F'20	Sp'21	F'21	Sp'22	F'22	Sp'23
MATH 5510	X	X	X	X	X	X	X	X	X	X	X	X
CHE 6010		X			X		X		X			X
ME 6040	X		X				X		X		X	
CHE 6140	X		X		X		X				X	
CHE 6210		X		X		X				X		X

In addition to these core courses, there were nine graduate elective courses offered in the Fall 2022 or Spring 2023 semester including one dual-listed 4000/5000 level course, four special topics courses, two non-thesis project courses, the CHE graduate seminar course, and a directed study course.

Use of Results to Improve Outcomes:

The College continues to increase its activities to recruit graduate students, and the department will be actively engaging in recruitment efforts during the 2023-2024 academic year with plans

for the Chair to attend the American Institute of Chemical Engineers annual meeting in November of 2023 where a table will be reserved for the department's participation at the Recruitment Fair. Both the department and College continue to increase communications to current students at the university who might be interested in the BS/MS Fast-Track programs. Recruitment of students directly from the department's CHE-BS program to join the CHE graduate program as either an MS student or a direct-admit PhD student has had a very positive impact. Building on a successful first-year recruitment effort, an increased emphasis will be made to recruit chemical engineering students as well as students in other project-related disciplines for participation in the NSF-funded NRT project.

PO4: STUDENT CULTURAL, PROFESSIONAL, AND ACADEMIC GROWTH

Define Outcome:

Provide a meaningful environment for student growth in cultural, professional and academic aspects including opportunities to develop as a future faculty member in an academic department.

Assessment Methods:

Chemical Engineering Graduate Research Association (CEGRA): The Chemical Engineering Graduate Research Association (generally referred to as CEGRA) is an organization led by CHE graduate students to provide a social and support network for graduate students in the CHE graduate programs. The organization has been in existence since 2003 with a constitution that is periodically reviewed by the membership. Monitoring of activities and updates from the CEGRA Faculty Advisor during departmental meetings and via discussions between the Faculty Advisor, CHE Department Chair and/or Graduate Program Coordinator occur periodically.

Criteria for Success (Thresholds for Assessment Methods):

Chemical Engineering Graduate Research Association (CEGRA): CEGRA maintains an active group of officers who lead regularly-scheduled meetings and social events.

Results and Analysis:

All students in the CHE department's graduate programs are encouraged to participate in CEGRA which provides extensive opportunities for personal enrichment by holding routine meetings, supporting social events, and coordinating the submission of requests to the TTU Student Monies Allocation Committee to support travel to national and international conferences and annual meetings of professional societies. In addition, some graduate students, especially MS-CHE students, have opportunities to serve as TA's.

Use of Results to Improve Outcomes:

The College continues to increase its activities to recruit graduate students, and the department will be actively engaging in recruitment efforts during the 2023-2024 academic year with plans for the Chair to attend the American Institute of Chemical Engineers annual meeting in November of 2023 where a table will be reserved for the department's participation at the Recruitment Fair. Both the department and College continue to increase communications to current students at the university who might be interested in the BS/MS Fast-Track programs. Recruitment of students directly from the department's CHE-BS program to join the CHE graduate program as either an MS student or a direct-admit PhD student has had a very positive impact. Building on a successful first-year recruitment effort, an increased emphasis will be made to recruit chemical engineering students as well as students in other project-related disciplines for participation in the NSF-funded NRT project.

PO5: SCHOLARLY ACTIVITIES**Define Outcome:**

Demonstrate scholarship through peer-reviewed/archival publications, externally sponsored projects, and presentation in national and international scientific meetings.

Assessment Methods:

External and Internal Funding Generated/Obtained: Reports are periodically requested from the TTU Office of Research (or obtained from its website) to provide details on external funding to faculty in the department. In addition, the department maintains a summary of funding status of graduate students in the program and frequently re-assesses this information in efforts to ensure that as many graduate students as possible are supported.

Criteria for Success (Thresholds for Assessment Methods):

External and Internal Funding Generated/Obtained: Faculty make efforts to secure external and internal funding.

Results and Analysis:

External and Internal Funding Generated/Obtained: Faculty make efforts to secure external and internal funding to support graduate students. For the 2022-2023 reporting period, four externally-funded grants with CHE faculty as PI or co-PI had funds allocated for CHE graduate student support.

In addition to attending and/or presenting at conferences, CHE students are actively involved in the on-campus Student Research and Creative Inquiry Day event. For the Spring 2023 event, two MS students presented along with eight BS students and 10 PhD students from the CHE department.

Use of Results to Improve Outcomes:

The College continues to increase its activities to recruit graduate students, and the department will be actively engaging in recruitment efforts during the 2023-2024 academic year with plans for the Chair to attend the American Institute of Chemical Engineers annual meeting in November of 2023 where a table will be reserved for the department's participation at the Recruitment Fair. Both the department and College continue to increase communications to current students at the university who might be interested in the BS/MS Fast-Track programs. Recruitment of students directly from the department's CHE-BS program to join the CHE graduate program as either an MS student or a direct-admit PhD student has had a very positive impact. Building on a successful first-year recruitment effort, an increased emphasis will be made to recruit chemical engineering students as well as students in other project-related disciplines for participation in the NSF-funded NRT project.

PO6: GRADUATION WITHIN TWO-YEAR WINDOW

Define Outcome:

Optimize graduate student time to graduation by providing courses and advising that facilitates student completion of the MS degree within a desired two-year window.

Assessment Methods:

1. External and Internal Funding Generated/Obtained: Reports are periodically requested from the TTU Office of Research (or obtained from its website) to provide details on external funding to faculty in the department. In addition, the department maintains a summary of funding status of graduate students in the program and frequently re-assesses this information in efforts to ensure that as many graduate students as possible are supported.
2. Periodic Review of Graduate Coursework and Curriculum: Progress made towards completion of required and elective courses is assessed using a variety of approaches. All graduate students are expected to file a program of study not later than the end of the semester in which they will have earned 15 credits towards their degree, and generally they are not allowed to register for subsequent semesters if this is not done. Additionally, a review of graduate courses and the curriculum is periodically completed through meetings between the Department Chair and the Graduate Program Coordinator to ensure that courses are offered in a time frame consistent with the program goal for time to graduation. Faculty advisors meet routinely with their advisees to discuss progress in courses and plans for follow-up courses. The Graduate Program Coordinator meets with all new students in the program to discuss courses, the program, and other critical matters. Additions, deletions, and/or changes to the graduate curriculum are first approved via the CHE Graduate Committee and subsequently via the College of Engineering's Graduate Executive Committee (of which the CHE Graduate Program Coordinator is a member), and then the Graduate School Executive Committee.

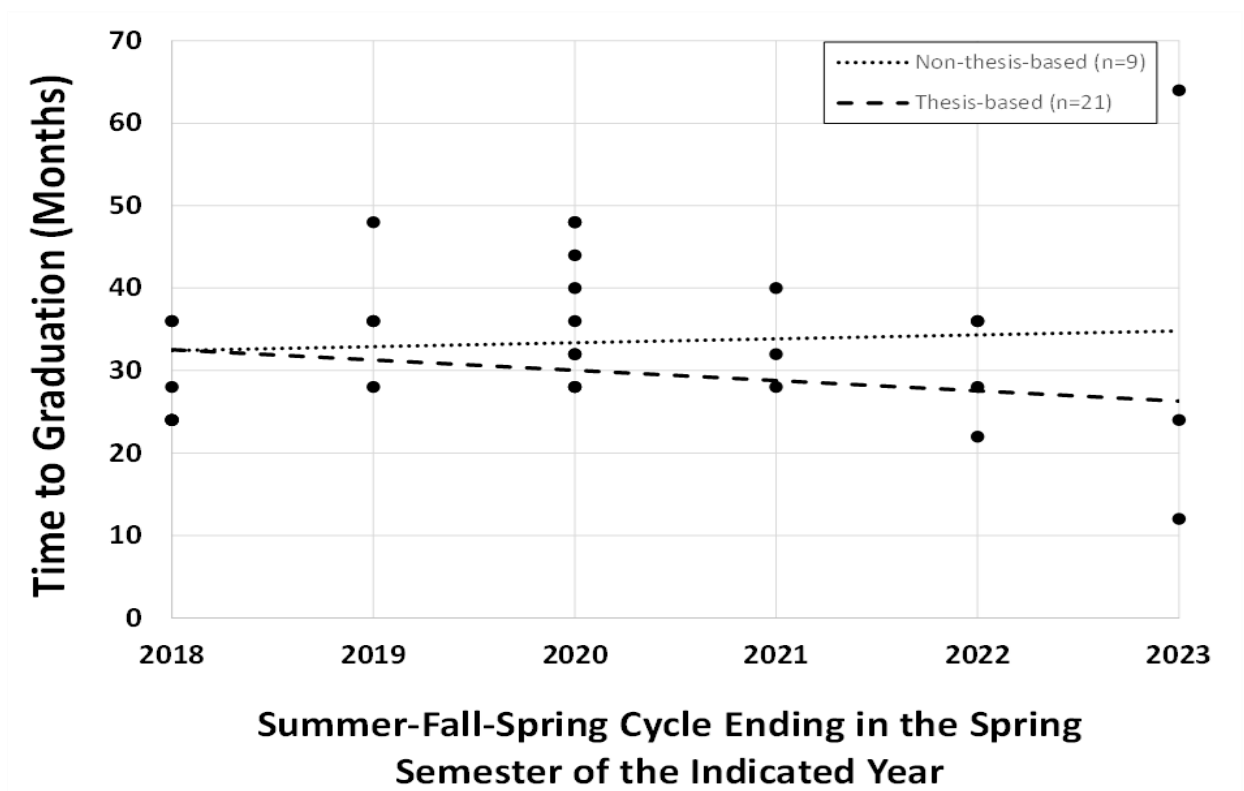
Criteria for Success (Thresholds for Assessment Methods):

1. External and Internal Funding Generated/Obtained: Documentation of internal/external grant funding that is used to support faculty research and graduate students.
2. Periodic Review of Graduate Coursework and Curriculum: Courses provide relevant training in advanced chemical engineering concepts. Required courses offered at a frequency to support timely progression towards degree completion. In general, these courses should be offered annually.

Results and Analysis:

As mentioned above, for the 2022-2023 reporting period, four externally-funded grants with CHE faculty as PI or co-PI had funds allocated for CHE graduate student support. In addition, other graduate students are supported as teaching assistants or research assistants from a number of other sources on-campus including through the department, Centers of Excellence, the College, and university.

Course offerings are routinely evaluated, and courses are offered at a frequency that provides the possibility for students to graduate in-line with the stated goal for time to graduation. Each student is assigned an advisor who routinely meets with the student. The average time to graduation for MS-CHE students over the last six years is on the order of 33.4 months overall with distribution as follows: 29.8 months for the 21 students graduating from the thesis-based MS-CHE program, 44.0 months for the three students graduating from the non-thesis-based MS-CHE program, and 40.7 months for the six direct-admit PhD students who earned their non-thesis-based MS-CHE degree along the way towards their PhD. The overall trendline regarding time to graduation for the thesis-based MS-CHE degree suggests a somewhat improving reduction in time to graduation. In fact, for this reporting period, one BS/MS fast-track student received his BS-CHE degree in May of 2022 and his MS-CHE degree only one year later in May of 2023. As an additional point, without considering the one outlier point in 2023, the time to graduation also seems to show a downward trend for non-thesis-based MS-CHE students.



Use of Results to Improve Outcomes:

The College continues to increase its activities to recruit graduate students, and the department will be actively engaging in recruitment efforts during the 2023-2024 academic year with plans for the Chair to attend the American Institute of Chemical Engineers annual meeting in November of 2023 where a table will be reserved for the department's participation at the Recruitment Fair. Both the department and College continue to increase communications to current students at the university who might be interested in the BS/MS Fast-Track programs. Recruitment of students directly from the department's CHE-BS program to join the CHE graduate program as either an MS student or a direct-admit PhD student has had a very positive impact. Building on a successful first-year recruitment effort, an increased emphasis will be made to recruit chemical engineering students as well as students in other project-related disciplines for participation in the NSF-funded NRT project.

SLO1: PROFICIENCY IN SCIENTIFIC INQUIRY

Define Outcome:

All students must demonstrate knowledge and proficiency in the method of scientific inquiry.

Assessment Methods:

1. Periodic Review of Graduate Coursework and Curriculum: Progress made towards completion of required and elective courses is assessed using a variety of approaches. All graduate students are expected to file a program of study not later than the end of the semester in which they will have earned 15 credits towards their degree, and generally they are not allowed to register for subsequent semesters if this is not done. Additionally, a review of graduate courses and the curriculum is periodically completed through meetings between the Department Chair and the Graduate Program Coordinator to ensure that courses are offered in a time frame consistent with the program goal for time to graduation. Faculty advisors meet routinely with their advisees to discuss progress in courses and plans for follow-up courses. The Graduate Program Coordinator meets with all new students in the program to discuss courses, the program, and other critical matters. Additions, deletions, and/or changes to the graduate curriculum are first approved via the CHE Graduate Committee and subsequently via the College of Engineering's Graduate Executive Committee (of which the CHE Graduate Program Coordinator is a member), and then the Graduate School Executive Committee.
2. Thesis Presentation and Defense, Publications, and Other Presentations: All students in the thesis-based MS program are required to complete a thesis presentation and defense. The presentation is completed in a public, seminar-type format at the end of the students' program with the student's thesis committee and others in attendance. Upon completion of the presentation, a question/answer session ensues, and then, with the audience dismissed, the committee discusses the presentation and defense and the student's overall performance in the program and decides whether the student has "passed." As the comprehensive exam is integrated with the thesis defense for MS students, questions may also be asked regarding coursework completed and student knowledge in his/her area. A non-thesis MS degree is also possible for students who desire a more course work intensive graduate degree and for students who are directly admitted to the PHD program. During their program, students are encouraged and provided the opportunity to be involved in development of manuscripts for submission for peer-reviewed conference proceedings and journal articles and to present at conferences and the on-campus Student Research and Creative Inquiry Day event.

Criteria for Success (Thresholds for Assessment Methods):

1. Periodic Review of Graduate Coursework and Curriculum: Courses provide relevant training in advanced chemical engineering concepts. Required courses offered at a frequency to support timely progression towards degree completion. In general, these courses should be offered annually.
2. Thesis Presentation and Defense: Thesis documents are published in the ProQuest Dissertations & Theses database. MS-thesis-based students are encouraged to submit a manuscript to a peer-reviewed journal though such submission is not required for

graduation. Non-thesis students submit a "binder" that provides documentation of the work completed for their non-thesis project. All MS students in the department present the outcomes from their thesis-related research or non-thesis project, as applicable.

Results and Analysis:

All MS-CHE students must demonstrate knowledge and proficiency in the method of scientific inquiry. Development of these skills is demonstrated via numerous means including: (1) satisfactory progress towards completion of the thesis research project as measured by grades posted during semesters in which a graduate student signs up for the CHE 6990 (Research and Thesis) course or, for those pursuing the non-thesis MS degree, satisfactory performance in the CHE 6970 project course; (2) completion of a written thesis (or for the non-thesis MS degree, submission of an organized project binder with synthesized material) with appropriate content and presentation format that is accepted by the student's advisor, the thesis/project advisory committee, and the Dean of the College of Graduate Studies; (3) oral presentation and defense of the thesis research (or non-thesis) project in front of the student's thesis committee, student peers, and the general chemical engineering faculty, and (4) remediation of any issues raised by either the committee at the time of signing of the program of study or at the time of completing the thesis/defense (or project).

Use of Results to Improve Outcomes:

An increased emphasis is being placed this year on MS-CHE students presenting at the Student Research and Creative Inquiry Day event.

SLO2: PROFICIENCY IN GRADUATE LEVEL CHEMICAL ENGINEERING COURSEWORK

Define Outcome:

All students must demonstrate proficiency in graduate level transport phenomena (including fluid dynamics), chemical thermodynamics, kinetics, and applied and computational mathematics. Indicators of content knowledge gains are reflected by consistent progress towards completion of required courses as shown in the programs of study as well as high grades in those courses.

Assessment Methods:

Periodic Review of Graduate Coursework and Curriculum: Progress made towards completion of required and elective courses is assessed using a variety of approaches. All graduate students are expected to file a program of study not later than the end of the semester in which they will have earned 15 credits towards their degree, and generally they are not allowed to register for subsequent semesters if this is not done. Additionally, a review of graduate courses and the curriculum is periodically completed through meetings between the Department Chair and the Graduate Program Coordinator to ensure that courses are offered in a time frame consistent with the program goal for time to graduation. Faculty advisors meet routinely with their

advisees to discuss progress in courses and plans for follow-up courses. The Graduate Program Coordinator meets with all new students in the program to discuss courses, the program, and other critical matters. Additions, deletions, and/or changes to the graduate curriculum are first approved via the CHE Graduate Committee and subsequently via the College of Engineering's Graduate Executive Committee (of which the CHE Graduate Program Coordinator is a member), and then the Graduate School Executive Committee.

Criteria for Success (Thresholds for Assessment Methods):

The four core courses in the MS-CHE graduate program focused on development of advanced skills in mathematics, thermodynamics, transport, and kinetics are given as follows:

- a. MATH 5510: Advanced Math for Engineers
- b. CHE 6010: Advanced Chemical Engineering Thermodynamics
- c. CHE 6140: Physics of Transport or ME 6040: Intermediate Fluid Mechanics
- d. CHE 6210: Advanced Kinetics

Results and Analysis:

All students must demonstrate proficiency in graduate level transport phenomena (including fluid dynamics), chemical thermodynamics, kinetics, and applied and computational mathematics. Completion of these courses as well as graduate electives is reflected in programs of study and student transcripts. Indicators of content knowledge gains are reflected by consistent progress towards completion of required courses as shown in the programs of study as well as high grades in those courses.

Use of Results to Improve Outcomes:

An increased emphasis is being placed this year on MS-CHE students presenting at the Student Research and Creative Inquiry Day event.

SLO3: PROFICIENCY IN ETHICS IN RESEARCH APPROACHES

Define Outcome:

All students must show knowledge and applied proficiency of ethics in research approaches (thesis-based) or other investigational approaches (non-thesis-based).

Assessment Methods:

1. Chemical Engineering Graduate Research Association (CEGRA): The Chemical Engineering Graduate Research Association (generally referred to as CEGRA) is an organization led by CHE graduate students to provide a social and support network for graduate students in the CHE graduate programs. The organization has been in existence since 2003 with a constitution that is periodically reviewed by the membership. Monitoring of activities and updates from the CEGRA Faculty Advisor

during departmental meetings and via discussions between the Faculty Advisor, CHE Department Chair and/or Graduate Program Coordinator occur periodically. CEGRA activities help create a culture for growing professional and other ethical behaviors.

2. CHE 6920 is a focused course offered each year. It includes research ethics, research methods, and professionalism in scholarly activities in addition to preparing students for proposal writing and presentations. It is required for students in the non-thesis-based MS program and an optional (often-taken) course for thesis-based MS students.
3. Thesis committee members provide input and guidance to students in class and research settings.

Criteria for Success (Thresholds for Assessment Methods):

1. Chemical Engineering Graduate Research Association (CEGRA): CEGRA maintains an active group of officers who lead regularly-scheduled meetings and social events.
2. CHE 6920: Topics related to ethics and safety are covered in this course.
3. Guidance of thesis committee members: Students meet routinely with graduate research advisors and make satisfactory progress towards degree objectives.

Results and Analysis:

All students must show knowledge and applied proficiency of ethics in research approaches. A focused course (CHE 6920) is offered each year to help students with these aspects, and it includes research ethics, research methods, and professionalism in scholarly activities in addition to preparing students for proposal writing and presentations. The vast majority of graduate students in the program take this course. Further, input and guidance from thesis committee members to students in class and research settings provide additional points for ensuring ethical behaviors.

Use of Results to Improve Outcomes:

An increased emphasis is being placed this year on MS-CHE students presenting at the Student Research and Creative Inquiry Day event.

SLO4: KNOWLEDGE OF CURRENT RESEARCH AND COMMITMENT TO LIFELONG LEARNING

Define Outcome:

All students must show knowledge of current and relevant areas of research and must demonstrate a commitment to the process of lifelong learning.

Assessment Methods:

1. Research Seminars Series broadens the students' exposure to current topics of relevance for the profession. The series seminars are offered every semester.
2. Student Thesis and Non-Thesis Committees include graduate faculty in CHE at TTU as well as committee members from outside the department and sometimes from outside the College of Engineering.

3. Non-thesis binders contain both original work and resources leveraged.
4. Chemical Engineering Graduate Research Association (CEGRA) provides opportunities for students to see the breadth and depth of knowledge associated with their discipline through participation in conferences and increased familiarity with other researchers' work.

Criteria for Success (Thresholds for Assessment Methods):

1. Research Seminar Series: Graduate student and faculty participation in on-campus seminars.
2. Student Thesis and Non-Thesis Committees: Programs of study are submitted and approved by student's committee. Changes are likewise reviewed and approved.
3. Non-thesis binders: Binders are received and held by student's faculty advisor.
4. Chemical Engineering Graduate Research Association (CEGRA): CEGRA maintains an active group of officers who lead regularly-scheduled meetings and social events. The CEGRA leadership also facilitates the process for obtaining funding to support graduate student travel to and presentation at conferences.

Results and Analysis:

All students must show knowledge of current and relevant areas of research (or other forms of inquiry for the non-thesis option) and must demonstrate a commitment to the process of lifelong learning. The Department offers a "Research Seminars Series" to broaden student exposure about current topics of relevance for the profession. This seminar series is conducted each semester. In addition, though the Chair of the student's thesis (or non-thesis) committee must be a graduate faculty in CHE at TTU, many graduate students have other thesis committee members who are from outside the department and in many cases outside of the College of Engineering. "Certificates of Approval" which are required to be signed by the thesis committee and included in the record for each student's thesis reflect this composition. Further, for students pursuing the non-thesis option, a binder containing content (both original work and resources that students reviewed during their project such as copies of peer-reviewed literature) must be submitted by the student for review and approval.

Use of Results to Improve Outcomes:

An increased emphasis is being placed this year on MS-CHE students presenting at the Student Research and Creative Inquiry Day event.

SLO5: SCHOLARLY WRITING

Define Outcome:

All thesis-based MS-CHE students are encouraged to have submitted, at the time of thesis defense, at least one manuscript based on his/her thesis project to a peer-reviewed journal. Graduate students also often author or co-author abstracts and conference proceedings. Further, MS-CHE (thesis-based) students are required to submit a thesis approved by their

thesis advisory committee and the College of Graduate Studies. Non-thesis MS-CHE students submit a binder containing original material including (for example) written work, computer codes, presentation materials, copies of peer-reviewed literature, etc.

Assessment Methods:

1. Thesis Presentation and Defense, Publications, and Other Presentations: All students in the thesis-based MS program are required to complete a thesis presentation and defense. The presentation is completed in a public, seminar-type format at the end of the students' program with the student's thesis committee and others in attendance. Upon completion of the presentation, a question/answer session ensues, and then, with the audience dismissed, the committee discusses the presentation and defense and the student's overall performance in the program and decides whether the student has "passed." As the comprehensive exam is integrated with the thesis defense for MS students, questions may also be asked regarding coursework completed and student knowledge in his/her area. A non-thesis MS degree is also possible for students who desire a more course work intensive graduate degree and for students who are directly admitted to the PHD program. During their program, students are encouraged and provided the opportunity to be involved in development of manuscripts for submission for peer-reviewed conference proceedings and journal articles and to present at conferences and the on-campus Student Research and Creative Inquiry Day event.

Criteria for Success (Thresholds for Assessment Methods):

1. Thesis Presentation and Defense, Publications, and Other Presentations: Thesis documents are published in the ProQuest Dissertations & Theses database. MS-thesis-based students are encouraged to submit a manuscript to a peer-reviewed journal though such submission is not required for graduation. Non-thesis students submit a "binder" that provides documentation of the work completed for their non-thesis project. All MS students in the department present the outcomes from their thesis-related research or non-thesis project, as applicable.

Results and Analysis:

All thesis-based MS-CHE students are encouraged to have submitted, at the time of thesis defense, at least one article based on his/her thesis project to a peer-reviewed journal. Graduate students also often author or co-author abstracts and conference proceedings. Further, MS-CHE (thesis) and PhD students are required to submit an approved thesis (or dissertation for doctoral students) that is approved by their thesis/dissertation advisory committees and the College of Graduate Studies. Non-thesis MS students submit a binder containing original material including (for example) written work, computer codes, presentation materials, copies of peer-reviewed literature, etc.

Use of Results to Improve Outcomes:

An increased emphasis is being placed this year on MS-CHE students presenting at the Student Research and Creative Inquiry Day event.

SLO6: PRESENTATIONS AT SCIENTIFIC MEETINGS**Define Outcome:**

All students are expected to present in international/national scientific meetings, and each advisor is to act as a mentor in this effort. As part of research group meetings, students often present findings from their research and/or from journal articles in the field.

Assessment Methods:

1. CHE Department Graduate Student Admissions and Success Database: The department collects information from all students applying for admission to its graduate programs and records several related items (e.g., GRE Scores, BS QPA, TOEFL scores, etc.) in a spreadsheet database. A separate spreadsheet is maintained in which metrics regarding student success (such as completion of core courses, time to completion, grades, indicators of funding, and other indicators of student progress) are tracked.
2. Chemical Engineering Graduate Research Association (CEGRA): The Chemical Engineering Graduate Research Association (generally referred to as CEGRA) is an organization led by CHE graduate students to provide a social and support network for graduate students in the CHE graduate programs. The organization has been in existence since 2003 with a constitution that is periodically reviewed by the membership. Monitoring of activities and updates from the CEGRA Faculty Advisor during departmental meetings and via discussions between the Faculty Advisor, CHE Department Chair and/or Graduate Program Coordinator occur periodically.
3. Diversity of Program Demographics: The diversity and student body demographics are routinely examined with this information being maintained in the Student Success Database. The departmental culture is inclusive, and the faculty and staff wholeheartedly seek to include diverse perspectives and experiences throughout curricular and extracurricular activities.
4. Thesis Presentation and Defense, Publications, and Other Presentations: All students in the thesis-based MS program are required to complete a thesis presentation and defense. The presentation is completed in a public, seminar-type format at the end of the students' program with the student's thesis committee and others in attendance. Upon completion of the presentation, a question/answer session ensues, and then, with the audience dismissed, the committee discusses the presentation and defense and the student's overall performance in the program and decides whether the student has "passed." As the comprehensive exam is integrated with the thesis defense for MS students, questions may also be asked regarding coursework completed and student knowledge in his/her area. A non-thesis MS degree is also possible for students who desire a more course work intensive graduate degree and for students who are directly

admitted to the PHD program. During their program, students are encouraged and provided the opportunity to be involved in development of manuscripts for submission for peer-reviewed conference proceedings and journal articles and to present at conferences and the on-campus Student Research and Creative Inquiry Day event.

Criteria for Success (Thresholds for Assessment Methods):

1. CHE Department Graduate Student Admissions and Success Database: Students' efforts related to scholarly activities including thesis and non-thesis topics, presentations, and publications are documented.
2. Chemical Engineering Graduate Research Association (CEGRA): CEGRA maintains an active group of officers who lead regularly-scheduled meetings and social events. The CEGRA leadership also facilitates the process for obtaining funding to support graduate student travel to and presentation at conferences.
3. Diversity of Program Demographics: Shared office space provides an opportunity for exchanging of ideas and ways of thinking.
4. Thesis Presentation and Defense, Publications, and Other Presentations: Students' efforts related to scholarly activities including thesis and non-thesis topics, presentations, and publications are documented.

Results and Analysis:

All thesis-based MS-CHE students are expected to present in national/international scientific meetings and/or the university's Student Research and Creative Inquiry Day, and each advisor is to act as a mentor in this effort. As part of research group meetings (and in graduate level courses such as the graduate seminar CHE 6920 course), students often present findings from their research and/or from journal articles in the field.

Use of Results to Improve Outcomes:

An increased emphasis is being placed this year on MS-CHE students presenting at the Student Research and Creative Inquiry Day event.

Summative Evaluation:

There is concern regarding the overall number of graduate students in the program, as the current number (per this report) of 21 (while still falling in the 3-4 students per faculty range) represents a significant reduction from the period of time in the 2014-2018 timeframe when the annual graduate enrollment in the department exceeded 30. Conversations are underway in the department regarding an on-line option for our CHE-MS program, and new areas of research emphasis are being explored. Along with these items, increased efforts focused on graduate recruitment are also planned for the new assessment cycle.

Assessment Plan Changes:

Not applicable at the present time.

Appendix 1: Curriculum Map Chemical Engineering MS

Table 1. Mapping of Assessment Approaches to Program and Student Learning Outcomes

Assessment Approach/Tool	Program Outcomes						Student Learning Outcomes					
	1 Sufficient Enrollment	2 Diverse Students	3 Rigorous Training	4 Meaningful Environment	5 Publications, Presentations	6 Time to Graduation	1 Research Skills	2 Content Knowledge	3 Ethical Behaviors	4 Research Depth	5 Writing Skills	6 Presentation Skills
Graduate Student Admissions and Success Databases	X	X				X					X	X
Chemical Engineering Graduate Research Association (CEGRA)				X	X				X	X		X
Diversity of Program Demographics		X							X			X
External and Internal Funding Generated/Obtained	X				X	X						
Graduate Student Enrollment Data	X	X										
Periodic Review of Graduate Coursework and Curriculum			X			X	X	X	X			
Thesis Presentation and Defense			X				X				X	X