

Chemical Engineering MS

Mission and Vision for the CHE-MS Program and Connections to the TTU Mission

Progress: Completed

Reporting Year: 2016-2017

Providing Department: Chemical Engineering MS

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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.

<from <https://www.tntech.edu/engineering/departments/che/about-che/missionvision>>

The Department of Chemical Engineering at TTU 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 and a PHD in Engineering with a concentration 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 NSF, DOE, and state and private sources among others. As we have been moving to a higher level of research excellence, students are receiving national accolades and some are entering the program with prestigious international fellowships from their governments and/or from international organizations. Faculty members work closely with colleagues in Electrical 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.

<from <https://www.tntech.edu/engineering/departments/che/graduate>>

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

Program Goal 1: Develop and Maintain a Sufficient Number of Graduate Students

Define Goal:

Program Goal 1: 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. Currently (per Fall 2016 census for the MS program and departmental data for the PHD program), the program shows 48% (16 students) are enrolled at the MS level and 52% (17 students) at the PHD level, the latter of which reflects three students who recently completed their MS in CHE and are now enrolled in the PHD program.

Intended Outcomes / Objectives:

Program Goal 2: Maintain a Diverse Graduate Student Body

Define Goal:

Program Goal 2: Maintain a diverse graduate student body consisting of domestic and foreign students including minorities and individuals of underrepresented groups. Currently (per Fall 2016 census), 39% overall (18% at the MS level) of the graduate students are female graduate students, and there are students from the USA, Bangladesh, India, Iran, Iraq, Malaysia, Nepal, Nigeria, Saudi Arabia, Serbia, and Taiwan.

Intended Outcomes / Objectives:

Program Goal 3: Provide Rigorous, Interdisciplinary, and Current Training in CHE

Define Goal:

Program Goal 3: Provide students with a rigorous, interdisciplinary, and current training through both course work and research projects in relevant areas of modern chemical engineering.

Intended Outcomes / Objectives:

Program Goal 4: Provide a Meaningful Environment for Student Growth

Define Goal:

Program Goal 4: 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.

Intended Outcomes / Objectives:

Program Goal 5: Demonstrate Peer-Reviewed Scholarship

Define Goal:

Program Goal 5: Demonstrate scholarship through peer-reviewed/archival publications, externally sponsored projects and presentation in national and international scientific meetings.

Intended Outcomes / Objectives:

Program Goal 6: Optimize Graduate Student Time to Graduation

Define Goal:

Program Goal 6: The average MS student is expected to graduate within two years, *i.e.*, complete a Fall, a Spring, a Summer, a Fall and a Spring term, then graduate.

Intended Outcomes / Objectives:

Student Learning Outcome 1: Acquisition of Research Skills

Define Goal:

Aid students in developing research skills

Intended Outcomes / Objectives:

Student Learning Outcome 1: All students must demonstrate knowledge and proficiency in the method of scientific inquiry.

Student Learning Outcome 2: Content Knowledge Gains

Define Goal:

Aid students in developing advanced content knowledge in chemical engineering and other areas related to their research

Intended Outcomes / Objectives:

Student Learning Outcome 2: All students must demonstrate proficiency on the fundamentals of transport phenomena (including fluid dynamics), chemical thermodynamics, kinetics, and applied and computational mathematics. The PHD students, in addition, must show proficiency in advanced methods related to these topics.

Student Learning Outcome 3: Awareness of Ethical Behaviors in the Profession

Define Goal:

Increase students' awareness of ethical behaviors and communications in the profession

Intended Outcomes / Objectives:

Student Learning Outcome 3: All students must show knowledge and applied proficiency of ethics in research approaches. A focused course (CHE 6920) is offered 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.

Student Learning Outcome 4: Increased Familiarity with Disiplinary and Interdisciplinary Research Areas in CHE

Define Goal:

Provide students with broad exposure to various areas of research in the chemical engineering discipline

Intended Outcomes / Objectives:

Student Learning Outcome 4: All students must show knowledge of current and relevant areas of research and must demonstrate a commitment to the process of life-long learning. The Department offers a "Research Seminars Series" to broaden the student exposure about current topics of relevance for the profession.

Student Learning Outcome 5: Development of Research-Focused Written Communication Skills

Define Goal:

Develop competence in science and engineering-based, peer-reviewed, written communication skills

Intended Outcomes / Objectives:

All MS students are expected to have submitted, at the time of thesis defense, at least one article based on his/her thesis project to a peer-reviewed journal. PHD students are expected to have submitted at least three articles. Programs of study (Templates are available on-line, and forms that have been approved are archived in the CHE office.) must reflect these expectations properly.

Student Learning Outcome 6: Development of Research Presentation and Networking Skills

Define Goal:

Assist students in developing research presentation skills and in networking to enhance exposure of research findings

Intended Outcomes / Objectives:

Student Learning Outcome 6: All students are expected to present in international/national scientific meetings, and each advisor is to act as a mentor in this effort.

Assessment: CHE Department Graduate Student Admissions and Success Database

Goal/ Outcome/ Objective: Program Goals 1, 2 and 6; Student Learning Outcomes 5 and 6

Type of Tool: Tracking Spreadsheet
Other

Frequency of Assessment: Data entered upon entrance of student into program and then periodically throughout the year

Assessment Methods:

Collection of admissions data (GRE Scores, BS QPA, TOEFL scores, etc.) for all students applying for admission to the program. The database is also used to track "Time to Completion", progress, and other measures of student success.

Assessment: Chemical Engineering Graduate Research Association (CEGRA)

Goal/ Outcome/ Objective: Program Goal 4; Student Learning Outcomes 4 and 6

Type of Tool: Other

Frequency of Assessment: Periodically throughout the year during department meetings

Assessment Methods:

CEGRA (Chemical Engineering Graduate Research Association) -- Monitoring of activities and updates from the CEGRA Faculty Advisor during departmental meetings.

Assessment: Diversity of Program Demographics

Goal/ Outcome/ Objective: Program Goal 2; Student Learning Outcomes 4 and 6

Type of Tool: FTE Enrollment
Tracking Spreadsheet
Other

Frequency of Assessment: Periodically throughout each year

Assessment Methods:

Diversity of Program Demographics -- The diversity and student body demographic is constantly monitored. The Department has been successful in maintaining the number of female students, domestic students, and international students. Currently (per Fall 2016 census), the program shows 39% female graduate students, and 52% of all CHE graduate students are enrolled in the Engineering PHD, a strong departure from the situation found years ago where no women and no PHD students were enrolled.

Assessment: External Funding Generated

Goal/ Outcome/ Objective: Program Goals 5 and 6

Type of Tool: Tracking Spreadsheet
Other

Frequency of Assessment: Annually

Assessment Methods:

External Funding Generated -- A summary of external funds generated by the CHE department using data provided by the Office of Research.

Assessment: Graduate Student Enrollment Data

Goal/ Outcome/ Objective: Program Goals 1 and 2

Type of Tool: FTE Enrollment

Frequency of Assessment: Annually

Assessment Methods:

Graduate Student Enrollment Data -- Enrollment data provided via the TTU Office of Institutional Research used to track enrollment trends in the MS-CHE program.

Assessment: Periodic Review of Graduate Coursework and Curriculum

Goal/ Outcome/ Objective: Program Goal 3; Student Learning Outcomes 1, 2, and 3

Type of Tool: Other

Frequency of Assessment: Periodically, or as the need arises

Assessment Methods:

Periodic Review of Graduate Coursework and Curriculum -- A review of graduate courses and curriculum to ensure currency. Recommendations from the Department's Graduate Committee are presented for discussion and approval by the faculty as a whole.

Assessment: Thesis Presentation and Defense

Goal/ Outcome/ Objective: Program Goal 3; Student Learning Outcomes 1-4

Type of Tool: Dissertation Criteria

Frequency of Assessment: Administered for each student prior to graduation

Assessment Methods:

Thesis Presentation and Defense -- An oral defense of the student's thesis is presented by the student to the Advisory Committee near the completion of the program. Questions regarding coursework and knowledge in their area of specialization form the basis for discussions.

Rationale for Outcomes and Assessments (Process of Data Analysis)

Goal/ Outcome/ Objective: This section provides a rationale for the utilization of particular assessment tools and data sources.

Type of Tool: Other

Frequency of Assessment: Annually and periodically throughout the year

Assessment Methods:

Graduate Student Enrollment Data -- Office of Institutional Research -- A direct measure of sufficient enrollment in the program to maintain a critical mass of students.

CHE Department Graduate Student Admissions and Success Database -- A direct assessment of program academic quality by the maintenance of appropriate admissions standards and that these standards are being consistently and uniformly applied. This database is also used to track a number of metrics regarding graduate student success.

Diversity of Program Demographics -- A measure of the potential for students to obtain/enhance their awareness of global and social issues.

Periodic Review of Graduate Coursework and Curriculum -- A periodic review of graduate course offerings and curriculum in order to ensure that the curriculum is both current & relevant to today's continuously evolving and highly technological society.

Thesis Presentation and Defense -- A direct measure by the student's Graduate Advisory Committee of the student's ability to conduct research and/ or engage in independent study; demonstration of an enhanced expertise in their area of specialization; and proficiency in written and oral technical communication.

CEGRA -- In 2003, the CHE graduate student body created the Chemical Engineering Graduate Research Association (CEGRA). This student run organization cares for the needs of the CHE graduate students, organizes events and provides feedback to the CHE faculty concerning the graduate program. CEGRA helps to coordinate the students travel to conferences.

External Funding Generated -- The level of external funding provides one indicator of the relevance of research to society at large. It also is an important measure of the extent of faculty engagement in externally funded research projects and a source of support for graduate students.

Results Associated with Program Goal 3 and Student Learning Outcomes 1-3

Results:

Periodic Review of Graduate Coursework and Curriculum (Program Goal 3; Student Learning Outcomes 1, 2, and 3; Conducted periodically, or as the need arises) [Existing tool] – The CHE-MS program has four core courses (CHE 6010, Advanced Chemical Engineering Thermodynamics; CHE 6210, Advanced Kinetics; CHE 6040, Intermediate Fluid Mechanics (offered with Mechanical Engineering); and Math 5510, Advanced Math for Engineers) that are typically required. Sometimes, a newer course (Physics of Transport which is offered as a special topics CHE 6810 course) is substituted for the fluids class. The remaining credit-hours to complete the coursework required for the MS Degree (24 course credits total) and the PHD (42-48 course credits total) are from electives offered in the Colleges of Engineering, Arts and Sciences, Education, etc.

Efforts have been focused on ensuring that a sufficient number and type of graduate courses are offered on a rotating basis to ensure that students are able to enroll in such courses in a timely manner consistent with the target times to graduation. Over the time frame covering Fall 2006 to Spring 2017, a number of graduate level courses have been offered each academic year as shown in the table below. These courses include 5000, 6000, and 7000 level courses appropriate for graduate students at the MS or PhD level.

Number of CHE Graduate Course Offerings by Semester (Fall 2006-Spring 2017)																						
	F'06	Sp'07	F'07	Sp'08	F'08	Sp'09	F'09	Sp'10	F'10	Sp'11	F'11	Sp'12	F'12	Sp'13	F'13	Sp'14	F'14	Sp'15	F'15	Sp'16	F'16	Sp'17
5000	2	1	3	3	0	2	1	2	1	0	1	2	0	1	1	2	1	1	1	1	0	1
6000	4	5	4	2	5	3	4	2	3	1	4	1	3	3	3	3	4	3	4	5	3	3
7000	2	2	3	2	3	2	2	2	0	2	1	2	1	1	0	1	2	2	1	1	2	2

Most MS students take CHE 6920, Graduate Seminar. This course covers a variety of topics of importance for a chemical engineering researcher and also generally provides opportunities for skills development in the areas of presenting technical information and proposal development. A formal plan for offering the graduate program's core courses (almost always 1/semester) as well as elective courses is consistently utilized. Annual review of the graduate program courses of study, offerings, and course content are used to monitor and continuously improve the rigor and relevance of the program.

Attachments:

Results Associated with Program Goal 3 and Student Learning Outcomes 1-4

Results:

Thesis Presentation and Defense (Program Goal 3; Student Learning Outcomes 1-4; Administered to each student prior to graduation) [Existing assessment tool] -- No significant changes (plus or minus) in student performance have been reported by faculty in regards to the performance of graduate students during their thesis presentation/ course study defense. At this time, the student thesis is reviewed and the defense is heard by the thesis committee. If satisfied, the committee then signs a form (available via the graduate studies website) stating that the student has passed the defense, with minimal notes (if desired) regarding the student's performance typically written on the reverse side in free form.

Attachments:

Results Associated with Program Goal 4

Results:

CEGRA (Program Goal 4) -- CEGRA holds routine meetings during the fall and spring semesters, and through the meetings a number of activities are pursued. CEGRA students are active participants at the annual cookout at Dr. Stretz's home. CEGRA also co-hosts (with the undergraduate AIChE Chapter) the annual department banquet.

Also, every semester since November of 2003 the CHE Department has organized the TTU CHE Seminar Series. This important activity dramatically improves the academic environment and provides a way for the Department to showcase our students, faculty and research infrastructure to visitors from outside. Visitors present a seminar, meet with both the graduate and undergraduate students and *interview* with the faculty to build external collaborations. CEGRA students have worked with faculty to produce a student handbook, written by the students, and posted on the CHE Department website. The handbook was last updated a few years ago, and so an update should be pursued.

Attachments:

Results Associated with Program Goals 1 and 2

Results:

Graduate Student Enrollment Data: The TTU Office of Institutional Research compiles detailed records of all students on campus. From these records, two categories of data regarding the CHE Master's program are summarized in Table 2 below for each of the last 12 years. These categories include: 1) the number of students graduating with an MS degree in CHE for each year since 2004 and 2) the number of students enrolled each year in either the CHE Master's program or those pursuing a doctoral degree with a concentration in CHE in the interdisciplinary College of Engineering PHD program.

Table 2: Number of CHE-MS Graduates and Graduate Student Enrollment in CHE

Number of CHE-MS Graduates and Graduate Student Enrollment in CHE															
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Graduates*	MS	10	11	5	4	4	6	4	3	4	2	4	4	6	6
	PHD														
Enrollment^	MS	16	10	17	18	12	11	8	5	8	12	16	16	16	16
	PHD	3	6	9	8	11	10	11	11	12	14	18	17	17	17
	Total	19	16	26	26	23	21	19	16	20	26	34	33	33	33

*Graduation data represent the sum of graduates from the Summer-Fall-Spring cycle prior to the Fall in the indicated years.

^Enrollment numbers are based on Fall census data for the indicated years, except for 2012-2014 PHD enrollments which are counted based on known students. Several new MS (and PHD) students have been admitted and are expected to enroll in Fall 2015.

A comparison of enrollment trends for all the BS-CHE, MS-CHE, and PHD-Engineering (with CHE concentration) programs is presented in Figure 1. The department has experienced tremendous growth in its BS enrollment and also in the number of students pursuing a PHD in engineering with a concentration in chemical engineering. During the time frame from 2002-2011, the enrollment in the MS-CHE program generally declined (Note: MS_CHE program enrollment was 20 and 18 for Fall 2002 and Fall 2003, respectively.) though enrollment spiked in 2006 and 2007. Since 2011, the MS-CHE program enrollment has been consistently increasing from a low of 5 in Fall 2011 to a Fall 2014 enrollment of 16 MS students. The increase in PHD (CHE) enrollments which was 0 in Fall 2002 is largely the direct result of a committed effort within the department to focus on the PHD program in order to increase the research stature of the program and more recently with the addition of new faculty to the program. The increase in the undergraduate enrollment is correlated with the launch in (2007) of a new concentration in biomolecular engineering within the BS-CHE program. The recent increase in the MS-

CHE enrollment may perhaps be associated with this new biomolecular engineering concentration (that had an undergraduate enrollment of 102 as of Fall 2014), new MS admission criteria that no longer require TTU STEM graduates to take the GRE, and also other opportunities, such as novel courses, to ease the transition of non-CHE BS graduates into the MS-CHE program.

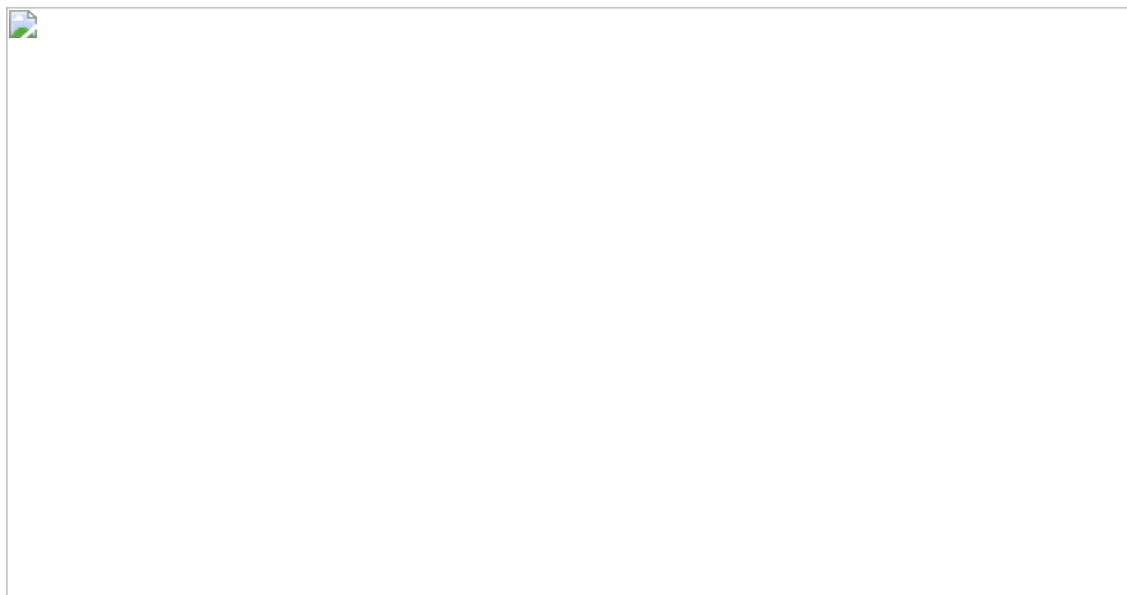


Figure 1: Enrollment trends in the CHE undergraduate and graduate programs

In 2014, the MS-CHE program was identified as low producing by the Tennessee Board of Regents (TBR) because the five year rolling average of the number of students graduating with an MS in chemical engineering had dropped below 5 (current number is at 3.4). Ultimately, the failure to attain benchmarks regarding the number of MS graduates over the last five to seven years is tied to three major issues: 1) the rapid and substantial growth in the undergraduate program; 2) the departure of several research active faculty prior to 2011; and 3) the fact that the department has chosen in the recent past to focus on the PhD program in an effort to increase the research stature of the program. Several corrective action measures that are focused on the following items are being pursued to remedy this: 1) Adding new faculty, TAs and staff; 2) Improving program quality; 3) Increasing efficiencies; and 4) Maximizing resources. A detailed corrective action plan has been submitted and presented to TBR.

CHE Department Graduate Student Admissions and Success Database (Program Goals 1 and 2; Data entered upon entrance of student into program) [Existing tool] -- Collection of admissions data (GRE Scores, BS QPA, TOEFL scores, BS Institution) for all students applying for admission to the program. Also, other metrics regarding student success (such as Time to Completion and Publications) are tracked.

- Admission Scores – New admission criteria were recently approved (2014) for the MS programs in the TTU College of Engineering. As such, admission decisions to the MS-CHE program are now based on a comprehensive assessment that includes such factors as whether the student has research experience at the undergraduate level in addition to factors such as GPA, GRE scores, etc.

<Admission requirements are posted in the TTU Graduate Catalog.>

MS-CHE applicants enrolled starting in Fall 2013 (n=3) and Fall 2014 (n=6) had an average undergraduate GPA of 3.34 and 3.40, an average GRE Verbal Score of 154 and 146.7, and an average GRE Quantitative Score of 154 and 159.7, respectively. For 2014, the CHE department received 28 applicants for either Summer 2014 (n=1) or Fall 2014 (n=27) admission into the MS-CHE program. Two of these applicants were denied admission. Of the 26 students admitted in full (n=22) or provisional (n=4) standing, nine applicants are graduates from the TTU CHE BS program (n=8) or the TTU Chemistry BS program (n=1). Under the new admission criteria, these nine students did not have to take the GRE in order to be eligible for admission. For the MS-CHE applicants who took the GRE (if required) and who were admitted in full or provisional standing for Summer (n=1) or Fall 2014 (n=25), average GPA and GRE scores are as follows: undergraduate GPA of 3.21; average GRE Verbal Score of 146.6; average GRE Quantitative Score of 155.7; and average GRE Analytical Writing score of 3.03. The two students who were denied admission had scores as follows: GPA of 2.47; average GRE Verbal Score of 136.5; average GRE Quantitative Score of 147.5; and average GRE Analytical Writing score of 2.50.

A total of 33 applicants applied to the CHE graduate programs for an entrance term sometime during 2017. Of those, 23 applied for admission to the MS-CHE program, and 10 applied for admission to the PHD program. Seven students were recommended for full admission to the MS-CHE program. Eight students were recommended for provisional standing to the MS-CHE program, and another eight were denied admission to the MS-CHE program. As indicated in the table below, among the students who submitted GRE scores (Note: TTU STEM graduates do not have to take the GRE.), the average Verbal plus Quantitative (V+Q) score was highest for those admitted in full standing and lowest for those denied admission. Similar outcomes were associated with the Analytical Writing section of the GRE.

	Full Standing			Provisional Standing			Denied		
	V	Q	AW	V	Q	AW	V	Q	AW
2017	150.4	154.6	3.7	145.1	154.1	3.0	142.3	154.6	2.9
	V+Q = 305.0			V+Q = 299.3			V+Q = 296.9		
	n=5			n=7			n=7		

- Time to Completion – Based on the most recent assessment, the five-year average duration to completion of the MS-CHE degree is 31.5 ± 13 months for the 24 students who graduated in the period (2006-2012). The median time to completion was 28 months. All but one graduate (who finished in 84 months, the maximum allowable) completed the program in 40 months or less. The average amount of time for the four students graduating in the Summer 2013-Fall 2013-Spring 2014 cycle is 28.9 months (Range: 21-33 months).
- Publications -- Most of our MS students are included in one or more publications based on their thesis research. Over the 2006-2011 period, 59 total peer-reviewed publications are in print, resulting in an average of 1.6 publications per student. This is the expected value given one publication per MS student and three per PHD student. Statistics for the 2012-2014 period will be compiled. At least 24 peer-reviewed publications with graduate students as authors were obtained in the 2014-15 reporting period.
- Student Presentations -- Students routinely attend conferences and present their research results. They also present research during the Student Research Day event held each spring on the TTU campus.

- Student performance is assessed in several ways. First, student grades are monitored by students, Faculty Advisors, and the Graduate School. The quality of research and MS student productivity/successes are monitored by Faculty Advisors, and a variety of methods specific to the Advisors are used. Master's students who serve as teaching assistants meet periodically with the instructors of the courses for which they TA. Students who are supported financially through the Centers of Excellence are generally expected to provide summary reports to the Centers to document the type and quality of research completed by the students.

Diversity of program demographics (Program Goal 2) -- The diversity and student body demographic is constantly monitored. The Department has been successful in increasing the number of female students considerably and plans are in place to increase enrollment of other minorities as well. For example, the Department is currently building a collaboration with a university in Brazil. During the period (2006-2014), the Department has observed some very successful cases of student productivity including the selection as National and International Awardees for these students. Based on the Fall 2014 census, the MS-CHE program enrollment (n=16) is 50% female graduate students, and the PHD enrollment (n=18) is 33% female, a strong departure from the situation found several years ago when no women and no PHD students were enrolled.

Also, in an effort to develop a diverse and competitive student body, the department utilizes the following approaches:

- Recruiting at national and regional AIChE (American Institute of Chemical Engineering) meetings and other venues;
- Networking and utilizing contacts inside and outside the U.S. to request potential candidates from other domestic universities and from international sources; and
- Developing brochures to be used in recruiting and program marketing.

The department has worked closely with the Office of Research and Graduate Studies (ORGS) and has admitted female and minority students with funding through University-level Fellowship programs. Several Diversity Fellows have been supported. For Fall 2014, the ORGS fully or partially supported six CHE graduate students. Two female African students have completed their MS degrees. One of these recently completed her PhD at TTU, and the other is currently pursuing her PHD in the department. These students have received for the first time (for TTU) prestigious graduate fellowships such as the AAUW and the Ivanhoe Foundation Fellowships and most recently a Schlumberger Foundation Faculty for the Future Fellowship. Figure 2 illustrates select demographic information regarding students admitted to the graduate program (2006-2012).

Figure 2: Numbers of female and Black/Hispanic students admitted between 2006-2012

Attachments:

Results Associated with Program Goals 5 and 6

Results:

External Funding Generated (Program Goal 5 and 6; Conducted periodically) [Existing tool] -- The central core of the Graduate Degree Program at the Department of Chemical Engineering at TTU is learning how to become a *professional researcher*. At the heart of this focus are the research areas and their relevance to the current problems faced by society and the profession. Students, in addition, systematically acquire knowledge by taking fundamental and elective courses to expand their knowledge of advanced chemical engineering concepts and support the successful driving of their research. Therefore, the focus research areas of the program are periodically assessed. During the 2011-2012 academic year, three graduate faculty of the Department took an active part in the new strategic planning process in the College of Engineering. The key result of this effort is the "21st Century Renaissance Engineering" Model adopted by the College (see a description at: <https://www.tntech.edu/engineering/strategicplan/>). In particular, as a key part of this effort, the College of Engineering (after a detailed assessment) identified six strategic research thrusts. Chemical Engineering has connections to four of them (Advanced Manufacturing · Nanoparticles and Proteomics in the Environment [now referred to as Biomolecular and Environmental Engineering and Science] · Energy Storage and Conversion · Resilient Infrastructure).

A summary of external funds generated (from 2007-08 through June 2017) by the CHE department faculty and CHE Center faculty (with tenure in CHE) using data provided by the TTU Office of Research is shown in the table below. While it is recognized that many externally and internally supported projects are interdisciplinary in nature, these activations reflect ones in which the Principal Investigator is a Faculty member in the CHE Department, a reporting approach based on typical TTU Office of Research practices.

The general noisy nature of funding is due to (1) movement of the faculty and (2) a small faculty, so fluctuations in any one program greatly affect the whole. Note that this reflects external grant funding only, and some students have been funded externally by their home governments or internally through the TTU Centers of Excellence and other units on campus. During the past few years, faculty in the department have been successful at securing funding via NSF through EPSCoR and other funding mechanisms.

Research Activations (\$) from Previous Ten Years for the CHE Faculty

Fiscal Year	CHE/Department Faculty	CHE/Center Faculty	Total
2007-08	\$124,730.00		\$124,730.00
2008-09	\$834,952.00	\$283,718.00	\$1,118,670.00
2009-10	\$366,860.00		\$366,860.00
2010-11	\$129,404.00	\$165,331.00	\$294,735.00
2011-12	\$105,243.00	\$266,561.00	\$371,804.00
2012-13		\$181,597.00	\$181,597.00
2013-14	\$381,057.00	\$176,097.00	\$557,154.00
2014-15	\$298,063.00	\$217,642.00	\$515,705.00
2015-16	\$329,147.00		\$329,147.00
2016-17	\$268,177.00		\$268,177.00

Attachments:

Results for Student Learning Outcome 5

Results:

Publications -- Several of our graduate students are included in one or more publications based on their thesis research. Sometimes such publications occur after graduation. During this reporting period, one MS student was first author on a peer-reviewed publication. Another MS student presented a paper at the ASEE Zone 2 meeting in Puerto Rico, and yet another MS student was a co-author on a doctoral student's first-author paper. At least one manuscript was published during this reporting period with the first author being a doctoral student in the program based on work completed as part of his MS thesis research at TTU. All theses and dissertations are archived through the ProQuest Dissertations & Theses Database. For the current period, there were six MS students who graduated with their degrees.

Attachments:

Results for Student Learning Outcome 6

Results:

Student Presentations -- Students routinely attend conferences and present their research results. They also present research during the Student Research Day event held each spring on the TTU campus. The number of poster presentations by degree objective of CHE students for each of the last six years is provided in the table below.

CHE Student Research Day Presentations by Degree Objective						
	2012	2013	2014	2015	2016	2017
BS	20	17	14	17	9	16
MS	2	6	6	11	12	13
PhD	16	12	9	12	10	10
Total	38	35	29	40	31	39

Attachments: