Institutional Effectiveness Report
2022-2023

Program: Mechanical Engineering BS

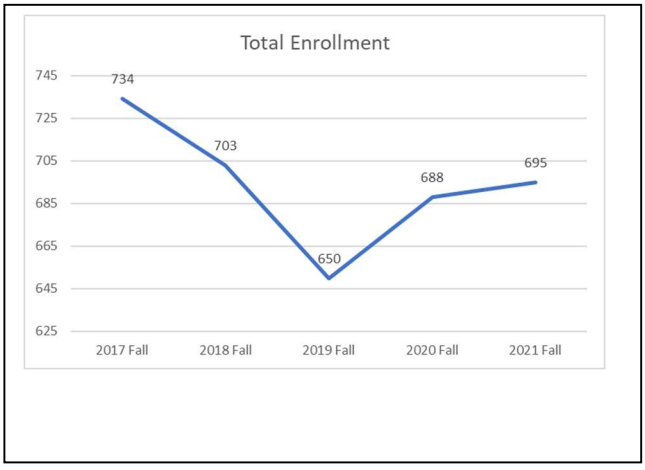
College and Department: College of Engineering – Mechanical Engineering

Contact: Mohan Rao, Chair of the Department

Mission: The Mechanical Engineering (ME) Department, within a regional and global context, will prepare its students for productive career in a competitive, dynamic, technologically-based society; will advance the knowledge of mechanical engineering principles and applications; and will serve the public.

VISION: The Mechanical Engineering Department at Tennessee Tech aspires to be recognized globally for outstanding education and research, leading to well-qualified engineers who are adaptive professionals, inquisitive, entrepreneurial and successful in engineering practice, research, and public service.

The B.S. in Mechanical Engineering (BSME) at Tennessee Tech is a traditional, on-campus lecture/laboratory program with on-ground course delivery offered almost exclusively during the day. There currently are no distance learning courses offered by the Mechanical Engineering Department. A co-op program is available through the Tennessee Tech Center for Career Development as an optional (but very popular) choice. The student enrollment trend in the ME department over past five years is shown in the Figure 1 below along with first time Freshman enrollment.



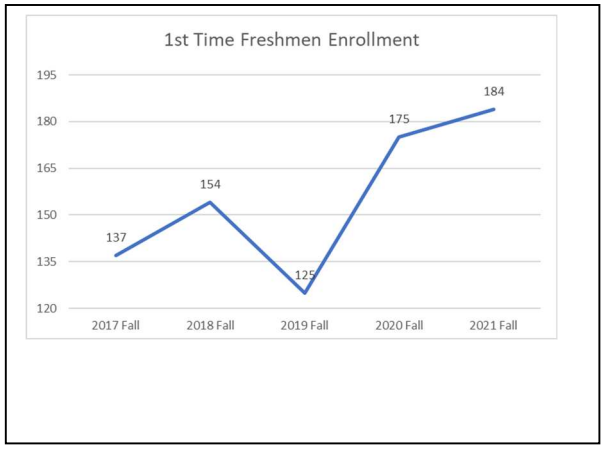


Figure 1. ME Department Enrollment Trends

The complete curriculum including flow charts and elective courses for the three ME degree options can be found on the TTU-ME Department website at

https://www.tntech.edu/engineering/programs/me/me-degree.php

The web site also lists all the courses, their syllabi, faculty and staff and other program highlights. The Bachelor of Science in Mechanical Engineering (BSME) degree offered by the Department of Mechanical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://abet.org.

Program Goals:

PG 1: Our graduates excel in diverse career paths using their engineering knowledge and professional skills to address complex problems and make positive impacts on society.

PG 2: Our graduates serve their profession and the public as ethical team members and leaders with awareness of modern issues, commitment to inclusive collaboration, and effective communication.

PG 3: Our graduates practice adaptive learning, expanding and enhancing their knowledge, creativity, and skills through professional development, continuing education, and/or earning advanced degrees.

Student Learning Outcomes:

It is expected that by the time of graduation, the Tech's ME students will have….

SLO 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

SLO 2: 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.

SLO 3: an ability to communicate effectively with a range of audiences.

SLO 4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

SLO 5: 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.

SLO 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

SLO 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Table 1. Student Outcomes mapped to Program Goals

ME Department Program Goals	Student Outcomes
Our graduates excel in diverse career paths using their engineering knowledge and professional skills to address complex problems and make positive impacts on society.	1, 2, 4, 6, 7

Our graduates serve their profession and the public as ethical team members and leaders with awareness of modern issues, commitment to inclusive collaboration, and effective communication.	3, 4, 5
Our graduates practice adaptive learning, expanding and enhancing their knowledge, creativity, and skills through professional development, continuing education, and/or earning advanced degrees.	1, 5, 6, 7

Assessment Methods:

1. *Alumni Survey (AS):* Alumni surveys are sent to graduates of the BSME program at one year and five years post- graduation. The fifteen questions on this survey occur in three sections. Section 1 (four questions) gathers data related to the Program Goals; Section 2 (seven questions) is used to assess alumni perception of ability with respect to ABET Student Outcomes; and Section 3 (four questions) requests text feedback on program strengths, weaknesses, suggested improvements, and open comments. The electronic Alumni Survey is issued annually in late fall via Machform and employs a 0-4 point scale in Sections 1 and 2, so there is no adjustment of scale prior to combining with other measures. Data from the Alumni Survey informs the evaluation of each Student Outcome (1-7).

2. *Co-Op Employer Survey (CES):* Approximately one-half of ME students participate in cooperative education agreements (co-ops) and/or internships during their program of study at Tech. For students who participate in co-op appointments sponsored through Tennessee Tech University's Center for Career Development, the co-op employers are required to complete a formal evaluation of the performance of each student at the end of each term in the co-op program. For College of Engineering students, the Tech Co-op Employer Survey (CES) also includes program- and Student Outcome-related assessment questions. These co-op surveys are considered a valuable source of direct feedback from employers, providing insight into student performance in-process, i.e., before they graduate. The Co-Op Employer Survey employs a 5-point scale (1 to 5), which is then converted to the 0-4 point scale by subtracting 1 point. Data from the Co-op Employer Survey informs the evaluation of five of the Student Outcomes (1, 3, 4, 5, 7).

3. *External Evaluation of Senior Design Projects (EESDP):* The External Evaluation of Senior Design Projects (EESDP) is conducted by evaluators invited from the ME External Advisory Board and from industry partners. These assess the Senior Design Projects and Project Presentations. The EESDP instrument uses the 0-4 pt. level-of-attainment scale. This instrument form has undergone three significant revisions, described in a later section, as part of the program's continuous improvement process. Data from the External Evaluation of Senior Design Projects informs the evaluation of five of the Student Outcomes (2, 3, 4, 5, 7). This assessment method is currently under discussion by the ME department Goals and Assessment Committee for possible revision.

4. *Instructional Outcomes Faculty Assessment (IOFA):* The Instructional Outcomes Faculty Assessment (IOFA) instrument provides a direct assessment of the level-of attainment of the students in a class with regards to the Course Instructional Outcomes. The Instructional Outcomes Faculty Assessment is surveyed for eight selected courses in the BSME curriculum (ME3001 Mechanical Engineering Analysis, ME3023 Measurements in Mechanical Systems, ME4910/2910 Professionalism and Ethics, ME 4020 Applied Machine Design, ME 4410 and ME 4420 Senior Capstone, ME 4720 Thermal Design, and ME4751 Energy Systems Lab). The assessment, completed by the course instructor at the end of each semester, consists of a detailed analysis of the extent to which the Course

Instructional Outcomes are achieved, as evidenced by student performance on specific test and homework problems, and other course assignments. The IOFA tool uses the 0-4 pt. level-of-attainment scale. Data from the Instructional Outcomes Faculty Assessment informs the evaluation of each of the Student Outcomes (1-7).

5. *Instructional Outcomes Student Survey (IOSS):* The Instructional Outcomes Student Survey (IOSS) is administered to students in eight selected courses in the BSME curriculum, same as for the IOFA above. The IOSS tool provides a pre/post self-assessment of student progress in achieving the Instructional Outcomes of the course. This is based on the difference between a student's perception of their level of knowledge for each Course Instructional Outcome upon entering a course and upon leaving the course. The IOSS survey is considered an indirect data source for assessment of Student Outcomes, as it requires a conversion through detailed mapping of a Course Instructional Outcomes to the Student Outcomes. The Instructional Outcomes Student Survey tool uses the 0-4 pt. level-of-attainment scale. Data from the IOSS informs the evaluation of each of the Student Outcomes (1-7).

6. *Senior Exit Interview Written Survey (SEIWS):* The Senior Exit Interview Written Survey (SEIWS) is one part of the Senior Exit Interview process. Students graduating from the BSME program provide self-assessment of their level of attainment of the ABET Student Outcomes, self-reporting of their engineering club and pre-professional activities while at Tennessee Tech, and text feedback regarding the BSME program and the ME Department. The Senior Exit Written Survey uses a quantitative 1-5 pt. “satisfaction” scale which is then converted to a 0-4 pt. scale for later combination with other assessment instruments results. The quantitative data is reviewed in conjunction with the Senior Exit Interview Oral Focus Groups, and the Goals and Assessment Committee summarize the qualitative comments. The data from the Senior Exit Interview Written Survey informs the evaluation of each of the Student Outcomes (1-7).

7. *Senior Exit Interview Oral Focus Groups (supporting source of evidence):* The Senior Exit Interview Oral Focus Groups (SEIOFG) process consists of an open discussion forum of graduating seniors with the ME chair and associate chair. The interview serves as a valuable source of suggestions for program improvement, as well as a source of supporting feedback on student performance. After receiving the feedback from the students, continuing concerns are compiled by the Goals and Assessment Committee and brought to the ME faculty for further discussion and possible action. Full records of student commentary are stored with all other assessment records.

8. *ME External Advisory Board Feedback (supporting source of evidence):* Feedback from the ME External Advisory Board is an important source of evidence for program improvement, guidance, and provides supporting evidence regarding the performance of students who are graduates of the BSME program. The External Advisory Board is composed of member representatives of several key constituency groups of the program, i.e., employers, alumni, and the professional community at large. Meeting minutes are kept with the other assessment data.

Expected Level of Attainment of the Student Outcomes

The expected level of attainment of Student Outcomes is scored with a 0-4 point level-of- attainment scale where each level is defined as 4 = Excellent, 3 = Good, 2 = Satisfactory, 1 = Low, and 0 = Negligible. Data from the assessment instruments are combined according to the evaluation plan to determine the final scored value each year for each Student Outcome.

A score of 3-to-4 is the desired level-of-attainment for each Student Outcome. A score between 2-to-3 is cause for review by the ME Goals and Assessments Committee, with possible actions and/or continued monitoring recommended to the ME faculty. A score lower than 2 requires corrective action to be taken by the ME faculty after review and recommendations for change by the ME Goals and Assessments Committee.

Results:

Assessment results for the academic year 2022-2023 are given in the table below, with additional comments as noted below the Table.

Academic Year Fall 2022 - Spring 2023							
	SO1	**SO2**	**SO3**	**SO4**	**SO5**	**SO6**	**SO7**
Alumni Survey	3	3	3	2.9	3.4	3.1	3.4
Co-op Employer Surveys	3.2	3.3	3.3	3.3	3.5	3.2	3.5
IOSS	3	2.9	2.9	2.9	3	2.9	2.9
Senior Exit	3.4	3.2	3.3	3.5	3.5	3.2	3.5
AVERAGE	**3.2**	**3.1**	**3.1**	**3.2**	**3.4**	**3.1**	**3.3**

Assessment Notes:

- In Fall 2021, the department adopted a plan for an overall change in process for assessment, evaluation, and change (AEC Plan). The two-year implementation cycle of the new AEC Plan impacts our data collection and tracking and reporting on outcomes in the transition years (2021-2023).
- We continue collection of data for four instruments reported on in the Table above, (Alumni Survey, Coop Employer Surveys, Instructional Outcomes Student Survey, and Senior Exit Survey),
- The two remaining instruments (Capstone Review, and Instructional Outcomes Faculty Assessment (IOFA)) are being significantly revised and are a work in progress.

Alumni Survey

- Eight respondents in Fall 2022, (four graduates in 2017, and four graduates in 2021)
- Low response rates continue to be of concern as to how useful this data is and what weighting it should receive in a quantitative sense.
- Improvement in response rates may be seen with a return to in-person alumni activities to build personal investment in responding to surveys
- The Goals and Assessment Committee team suggests an early response incentive such as TTU swag or gift certificate to see if such incentive helps the overall response rate.
- It is important to capture the number of alumni the survey is sent out to, as that is handled by the Alumni Center, and we need to obtain that number for next year and past years if possible, in order to report % return rates.

- The written feedback is considered useful in a qualitative sense, even if the number of respondents is low. The Goals and Assessment committee will continue its practice of preparing a summary of comments to be discussed in faculty meetings and with the EAB.

Co-op Employer Surveys

- 13 Respondents in Summer 2022, 9 respondents in Fall 2022, 14 respondents in Spring 2023
- The Goals and Assessment Committee is considering whether updated weighting should be applied to the data prior to combining into an overall average score for the SOs as is current practice.
- Observations and suggestions made in the 2021-2022 are still valid.

IOSS

- Response rates for the IOSS are low, approximately 10-30%
- In the coming year, we will return to the practice of in-class completion of the survey rather than relying on students to complete it outside of class via email notification.
- The Goals and Assessment Committee suggest expanding the use of the IOSS for all ME courses, not just the current seven (ME2910, ME3023, ME4020, ME4720, ME4751, ME4410, ME4420). Since this is data where students are direct reflecting on their pre and post ability with learning objectives of a course, the faculty can benefit by observing trends in the student perception in their course while considering course improvements.

Senior Exit

- In Fall 2022, 8 of 33 (24%) BSME degree candidates answered the survey
- In Spring 2023, 22 of 75 (29%) answered the survey
- The department has implemented some changes to how and when the surveys are conducted in order to increase response rate, however, these changes have not resulted in a marked increase as of yet. Additional ideas will be generated and discussion with student leaders as to how to improve the feedback percentages will be reported on in the next cycle.

IOFA

- Quantitative data was not assessed for 2022-2023.
- A modified IOFA instrument has been developed and proposed for use. The department is reviewing the new instrument and will implement it along with the expanded use of the IOSS for all ME courses.

Capstone Review

- Capstone Review data generated by external panels are on hold for 2021-2023 as the new AEC Plan develops the departmental rubrics for the SOs, including performance indicators with four levels.
- Note that the prior practice of engaging external reviewers to participate in Capstone Review was a challenge (due to numbers of student teams increasing, and scheduling for external reviewers to attend presentations, and time expectations), therefore the department decided to

proceed with involving all departmental faculty in regular review of the Capstone artifacts (Reports and Presentations).

- The extensive body of student data that are contained in the Capstone Design Reports and Presentations are central to our new AEC Plan. This data has been collected and is awaiting review. Use of new rubrics that facilitate the assessment on four of the SOs are still a work in progress from 2021-2022. Outcomes will be detailed in the next year IE report when all seven SOs will have been assessed and evaluated via the Capstone Projects.

Modifications for Improvement:

Continuous Improvement Plan for 2023-2024

The ME department Goals and Assessment Committee is facilitating the department's implementation of the new paradigm for assessment and continuous improvement that was adopted in Fall 2021. Work is ongoing in the stepwise two-year implementation of the new Assessment, Evaluation, and Change (AEC) Plan during Fall 2023-Spring 2024.

Change 1: Implement a Cycle of Assessment, Evaluation, and Change (AEC) for the seven student outcomes on a two-year cycle schedule, see Figure 1. The new AEC plan replaces the current practice of obtaining data every semester in seven courses using the Instructional Outcomes Student Survey and the Instructional Outcomes Faculty Assessment.

Student Outcome	20-21	21-22	22-23	23-24	24-25	25-26
SO 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.		A	E C	A	E C	A
SO 2. 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.			A	E C	A	E C
SO 3. An ability to communicate effectively with a range of audiences.		C A	E C	A	E C	A
SO4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.		A	E C	A	E C	A
SO5. 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.		A	E C	A	E C	A
SO 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.			A	E C	A	E C
SO 7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.			A	E C	A	E C

Figure 1. Two-year cycle for ME Program **Assessment (A), Evaluation (E), and Change (C).**

Change 2

Develop and Apply Rubrics to Student Artifacts at Programmatic Level

- AEC Rubrics for levels of attainment for SO1, SO3, SO4, and SO5 were completed by faculty teams in Spring 2022
- Applying these AEC rubrics to assess student artifacts (Senior Capstone Project Reports and Presentations) is a work in progress.
- Performance indicators (PI) were identified for SO2, SO6, and SO7 with full faculty participation in the Fall 2022 retreat
- Teams of faculty for SO2, SO6, and SO7 were facilitated by a member of the Goals and Assessment Committee to develop AEC rubrics for levels of attainment of the performance indicators.
- During Faculty meetings in Fall 2023, student artifacts from Capstone Design will be assessed using the seven rubrics to generate baseline data using the new AEC Rubrics.

Change 3: ME department faculty are participating in a pilot program with the CITL and iLearn support staff to use the Learning Outcomes tool in their iLearn courses.

- The learning materials, assignments, and rubrics in an iLearn course can be tied directly to the Student Outcomes and Performance Indicators.
- The pilot use of the iLearn Learning Outcomes tool can generate data that shows how students are performing within courses against the departmental AEC Plan. The data can be aggregated across the courses taught by these faculty to observe a more granular assessment of student growth in attaining the SO.
- The data collected via this pilot program may offer justification to adopt this method to inform the newly modified IOFA.

Change 4: Actions to improve the SO3 communication with solid modeling and technical drawings

- This change is informed by prior years' assessment, both in course and at the program level, that indicates students are not proficient with solid modeling and technical drawing as graduating seniors. In addition, alumni and graduating seniors indicated that SOLIDWORKS is more useful to their careers than AUTOCAD.
- In Fall 2021, the ME3001 Mechanical Engineering Analysis course which is required by all ME majors in the program of study, adopted use of SolidProfessor as a required text for the course, and implemented some assignments meant to help students refresh and/or develop skills with 3D modeling and communication using SOLIDWORKS.
- SolidProfessor is a four-year license to a web-based set of resources (videos, reading materials, and certifications) that ME students can purchase ($120). Requiring this as a text for ME3001 means all ME majors will have access to this resource for continued use while completing other courses in the ME program of study.
    - SolidProfessor has learning modules to develop skill with solid modeling, technical drawings, design for manufacturing, etc
    - Additional ME courses can leverage the student access to this learning resource by modifying existing and/or developing new assignments to require use of solid modeling and technical drawing
- In Fall 2022, the ME3001 course continues use of SolidProfessor, with a re-directed focus on using the inbuilt training modules to assist students' learning with Matlab, rather than using SP

to train on 3D modeling. Students are encouraged to self-learn with SP to enhance their use of SOLIDWORKS as needed.

- This practice of using SP in ME3001 will continue until such time as all ME first year students are taking ME Fundamentals 1 and ME Fundamentals 2, to ensure all ME majors have access to this training platform to update their skills as needed.

Change 5: Implement a pilot offering of two required ME courses in the first year as a sequence, ME Fundamentals 1 (2 cr hr) and ME Fundamentals 2 (2 cr hr).

- Our departmental data, and review of engineering education literature, informs our commitment to programmatic and pedagogical changes starting in the first year of students' program of study.
- A first-year experience for ME majors was piloted in Fall 2022. With permission from the General and Basic Engineering department, ME fundamentals 1 was offered in Fall 2022 to two sections of ENGR1110 Engineering Graphics, to a cohort of 39 students total, with the remaining 200+ ME first year majors taking the traditional ENGR1110 and/or ENGR1120 in their first semester.
- The learning outcomes for ME Fundamentals 1 have been established to engage students in their first semester as they learn about the ME profession during their first year at Tenn Tech. The goal is to help build students' awareness of the holistic nature of the profession in terms of knowledge, skills, and abilities (KSAs) and how they will attain these necessary KSAs for their chosen profession.
- ME Fundamentals 2 was offered in Spring 2023 to two sections of ENGR1120 Programming, with 20 of the 39 students from ME Fundamentals 1 continuing on in ME Fundamentals 2. Drop in continuance was due participants being mechatronics majors and not needing the regular ENGR1120 programming.
- In Fall 2023, 90 first year students are enrolled in three special sections of ENGR1110 (-021,-022, -023) and the course is co-taught by an ME faculty member and faculty from General and Basic Engineering.

List of Appendices:

- Appendix 1: Curriculum Map

Appendix 1: Curriculum Map

Course	Student Outcomes I = Introduce, R = Reinforce, D = Demonstrate						
Number and Title	**1**	**2**	**3**	**4**	**5**	**6**	**7**
ME 2330 Dynamics	I						I
ME 2910 Professionalism and Ethics			R	D	R		I
ME 3001 Mechanical Engineering Analysis	I				I	I	I
ME 3010 Materials & Processes in Manufacturing	I	I		I			
ME 3023 Measurements in Mechanical Systems	R			I	I	R	I
ME 3050 Dynamic Modeling & Controls	I	I					
ME 3060 Dynamic Modeling & Controls Lab			I		I	R	I
ME 3210 Thermodynamics I	I						
ME 3220 Thermodynamics II	R	I		I			
ME 3610 Dynamics of Machinery	R	I		I	I		
ME 3710 Fluid Dynamics	R						
ME 3720 Heat Transfer	R						
ME 4010 Machine Design	R	R		I		I	
ME 4020 Applied Machine Design	D	D	R	I	I	R	R
ME 4410 Senior Design Project I	D	R	R	R	R		D
ME 4420 Senior Design Project II		D	D	D	D	D	D
ME 4720 Thermal Design	D	D	R	I	I	R	R
ME 4751 Energy Systems Lab	R					D	