# Institutional Effectiveness Report
# 2019-20

**Program:** Mechanical Engineering BS

**College and Department:** College of Engineering – Mechanical Engineering

**Contact:** Mohan Rao

**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.

**Program Goals:**

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

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.

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

**Student Learning Outcomes:**

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

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

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

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

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

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.

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

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

A departmentally developed curriculum map can be found in Appendix 1 that shows the connections between courses and student learning outcomes.

Student Outcomes mapped to PEOs

| ME Department PEOs | 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 learning 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 Educational Objectives; 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).

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:**

*SO 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | 3.0 | 2.9 | 2.9 | 3.0 | 2.9 | 2.4 |
| Co-op Employer Survey | 3.2 | 3.0 | 3.1 | 3.2 | 3.2 | 3.2 |
| Grades in STEM Courses (Math, Chemistry, Physics, Engineering). | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | |
| Instructional Outcome – Faculty Assessment | | | | 3.4 | 3.1 | 2.8 |
| Instructional Outcome – Student Survey | 2.7 | 2.6 | 2.7 | 2.8 | 2.8 | 2.9 |
| Senior Exit Interview Written Survey | | 3.6 | 3.7 | 3.8 | 3.4 | 3.5 |
| Overall Level of Attainment | 3.0 | 3.0 | 3.1 | 3.2 | 3.0 | 3.0 |

Student Outcome 1 was scored a 3.0 which meet the program's desired level of attainment of between 3 and 4.

*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.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | | 2.7 | 2.7 | 3.0 | 2.8 | 2.3 |
| External Evaluation of Senior Design Projects | | | | 3.3 | 2.8 | 3.0 |
| Instructional Outcome – Faculty Assessment | | | | 3.5 | 3.1 | 2.7 |
| Instructional Outcome – Student Survey | 2.8 | 2.6 | 2.8 | 2.9 | 2.7 | 3.0 |
| Senior Exit Interview Written Survey | | 3.5 | 3.5 | 3.7 | 2.9 | 3.4 |
| Overall Level of Attainment | 2.8 | 2.9 | 3.0 | 3.3 | 2.9 | 2.9 |

Student Outcome 2 was scored a 2.9; this outcome and results will be reviewed by the ME Goals and Assessments Committee; and recommendations for potential actions leading to improvement will be shared and discussed with the ME faculty during the annual Fall 2020 retreat.

*SO3. An ability to communicate effectively with a range of audience.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | 2.2 | 2.8 | 3.1 | 2.9 | 3.1 | 2.3 |
| Co-op Employer Survey | 3.2 | 2.4 | 2.9 | 3.0 | 3.0 | 3.2 |
| External Evaluation of Senior Design Projects | | | | 3.3 | 2.6 | 3.0 |
| Grades in Communication Courses (Writing and Speech) | 3.6 | 3.6 | 3.6 | 3.6 | | |
| Instructional Outcome – Faculty Assessment | | | | 3.4 | 3.1 | 3.1 |
| Instructional Outcome – Student Survey | 3.0 | 3.0 | 2.9 | 3.0 | 2.9 | 3.0 |
| Senior Exit Interview Written Survey | | 3.5 | 3.4 | 3.6 | 2.9 | 3.3 |
| Overall Level of Attainment | 3.0 | 3.1 | 3.2 | 3.3 | 2.9 | 3.0 |

Student Outcome 3 was scored a 3.0 which meet the program's desired level of attainment of between 3 and 4.

*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.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | 2.5 | 2.8 | 3.1 | 2.7 | 3.3 | 2.6 |
| Co-op Employer Survey | 3.2 | 2.5 | 2.9 | 3.0 | 3.1 | 3.3 |
| External Evaluation of Senior Design Projects | | | | 3.3 | 2.7 | 2.9 |
| Grades in General Education Courses | - | 3.0 | 3.0 | 3.0 | | |
| Instructional Outcome – Faculty Assessment | | | | 3.3 | 2.8 | 2.4 |
| Instructional Outcome – Student Survey | 2.6 | 2.2 | 2.9 | 2.8 | 2.7 | 2.8 |
| Senior Exit Interview Written Survey | | 3.9 | 3.6 | 2.9 | 3.0 | 3.4 |
| Overall Level of Attainment | 2.8 | 2.9 | 3.1 | 3.0 | 2.9 | 2.9 |

Student Outcome 4 was scored a 2.9; this outcome and results will be reviewed by the ME Goals and Assessments Committee; and recommendations for potential actions leading to improvement will be shared and discussed with the ME faculty during the annual Fall 2020 retreat.

*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.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | 2.4 | 3.0 | 3.3 | 2.9 | 3.4 | 3.0 |
| Co-op Employer Survey | 3.7 | 3.5 | 3.5 | 3.5 | 3.5 | 3.6 |
| External Evaluation of Senior Design Projects | | | | 3.3 | 2.5 | 3.0 |
| Instructional Outcome – Faculty Assessment | | | | 3.6 | 3.3 | 2.9 |
| Instructional Outcome – Student Survey | 3.0 | 2.9 | 3.0 | 3.0 | 2.9 | 3.1 |
| Senior Exit Interview Written Survey | | 4.0 | 4.0 | 4.0 | 3.4 | 3.5 |
| Overall Level of Attainment | 3.0 | 3.3 | 3.4 | 3.4 | 3.2 | 3.2 |

Student Outcome 5 was scored a 3.2 which meet the program's desired level of attainment of between 3 and 4.

*SO6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | 3.1 | 2.8 | 3.0 | 2.9 | 3.1 | 2.9 |
| Co-op Employer Survey | | | | | | 3.2 |
| Instructional Outcome – Faculty Assessment | | | | 3.6 | 3.1 | 2.8 |
| Instructional Outcome – Student Survey | 2.8 | 2.6 | 2.7 | 2.9 | 2.9 | 2.9 |
| Senior Exit Interview Written Survey | | 3.4 | 3.5 | 3.6 | 3.2 | 3.4 |
| Overall Level of Attainment | 3.0 | 2.9 | 3.1 | 3.2 | 3.1 | 3.0 |

Student Outcome 6 was scored a 3.0 which meet the program's desired level of attainment of between 3 and 4.

*SO7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.*

| Assessment Instrument | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|---|
| Alumni Survey | 2.7 | 3.0 | 3.4 | 3.1 | 3.4 | 3.3 |
| Co-op Employer Survey | 3.3 | 3.0 | 3.1 | 3.2 | 3.2 | 3.4 |
| External Evaluation of Senior Design Projects | | | | 3.4 | 2.7 | 3.3 |
| Instructional Outcome – Faculty Assessment | | | | 3.3 | 2.7 | 2.7 |
| Instructional Outcome – Student Survey | 2.7 | 2.4 | 2.6 | 2.7 | 2.9 | 2.9 |
| Senior Exit Interview Written Survey | | 3.8 | 3.3 | 2.3 | 3.3 | 3.6 |
| Overall Level of Attainment | 2.9 | 3.1 | 3.1 | 3.0 | 3.0 | 3.2 |

Student Outcome 7 was scored a 3.2 which meet the program's desired level of attainment of between 3 and 4.

**Modifications for Improvement:**

*SO 2, SO 3, SO 4, SO 5, SO 7*

Feedback from evaluators for the Senior Design Project emphasized the need to impress upon students in design classes the importance of taking the time to analyze their designs before they begin building physical prototypes. Several members of the EAB support the program by sponsoring projects through their companies and also by offering their time to judge the projects during the annual showcase day. The incorporation of additional professional skills like communications, ethics, teamwork, and lifelong learning was also a need that they identified.

Changes are being brought on-line in the culminating two-semester Senior Design Project courses, ME 4410 and ME 4420, to include Design Project Portfolios for project management, analysis, and

presentation. Instructional focus has been directed at clarity in project expectations, rigor of project topic, analysis, and design, and development of students' project management and decision-making skills. The Senior Design Project Portfolio will consist of two parts; one is an instructor-developed Course Portfolio, referred to as the Capstone Handbook, and the second is the student-team-generated Design Project Portfolio. Both items are rendered electronically in Microsoft OneNote notebooks, originally setup in Microsoft SharePoint.

**Appendices**

1. Curriculum Map

## Appendix 1: Curriculum Map

| Course | Student Outcomes<br>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 | |