# Institutional Effectiveness Report
# 2020-21

**Program:** Manufacturing & Engineering Technology BS

**College and Department:** College of Engineering – Manufacturing & Engineering Technology

**Contact:** Fred Vondra

**Mission:** To graduate innovative Technologists or Applied Engineers who solve technological challenges to meet societal needs.

The BSET program at TTU 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 Manufacturing and Engineering Technology Department. A co-op program is available through the TTU Office of Career Services as an optional (but popular) choice.

**Program Goals:**

Graduates of the B.S. in Engineering Technology (ET) Program will

1. attain and succeed in positions related to Mechatronics Engineering Technology and Engineering Technology Management;

2. advance their careers and continue their professional development by pursuing graduate studies, attending workshops, obtaining certification and joining professional organizations;

3. succeed as leaders and managers in areas such as foundry operations, additive manufacturing, robotics, and industrial management.

**Student Learning Outcomes**

1. An ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline;

2. An ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline;

3. An ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to locate and apply appropriate technical literature;

4. An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes, and

5. An ability to function effectively as a member as well as a leader on cross-functional teams toward a common goal.

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

**Assessment Methods:**

1. *Alumni Survey: Indirect Assessment Tool:* Historically, alumni surveys have been used for program assessments since the first National Association of Industrial Technology (NAIT) accreditation in 1982. The department has administered the assessment instruments, analyzed and summarized the data, and presented the summary to the faculty for discussions, suggestions, and identification of necessary actions. The format of the alumni survey, which has been recently updated, is designed to assess ETAC of ABET Student Outcomes (1)-(5) and provide information related to the Program Educational Objectives. The survey is conducted every three years to evaluate the professional growth of our graduates.

   The alumni survey employs a 5-point "agree/disagree" scale (1 to 5), which is later converted to a 0-4 level-of-attainment scale by simply subtracting 1 point.

2. *Co-op Employer Survey: Direct Assessment Tool*: Around one-fifth of MET students participate in co-ops or internships during their time at Tennessee Tech. For co-op jobs sponsored through the Tennessee Tech Office of Career Development, the co-op employers are required to complete a formal evaluation of the performance of each student at the end of each co-op semester. In addition, employers of College of Engineering students are asked to respond to additional assessment questions, some of which are related to Student Outcomes. Co-op surveys are a valuable source of feedback directly from employers of our students, providing insight into their 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 level-of-attainment scale.

3. *External Assessment of Senior Projects: Direct Assessment Tool:* This assessment method was first introduced in Spring 2014 after the decision to pursue ETAC of ABET accreditation was made. The Manufacturing and Engineering Technology Advisory Board (METAB) members are used as external evaluators to assess the senior project presentations. A new evaluation form was developed for this purpose. The external evaluation of senior projects assessment tool uses the 0-4 level of attainment scale.

4. *Faculty Course Assessment Report (FCAR): Indirect Assessment Tool:* This assessment tool was added in Spring 2014 after the decision was made to pursue ETAC of ABET accreditation. This measurement tool provides an assessment of the level-of-attainment of the students in a class with regard to the course's instructional outcomes. The assessment is done by the course instructor at the completion of the course. Each of the instructional outcomes associated with a student outcome is scored on the faculty course assessment Report using a 0-4 level-of-attainment scale.

5. *Graduating Senior Exit Surveys/Interviews: Indirect Assessment Tool:* A written survey is one part of the Graduating Senior Exit Interview process. The Senior Exit Survey for the BSET program allows graduating seniors to provide feedback regarding the faculty, the department, the career services, and their perceived attainment of the ETAC of ABET Student Outcomes. The Graduating Senior Exit Survey uses a 1-5 "satisfaction" scale, which is then converted to the 0-4 level-of-attainment scale. The second part of this survey process is that each graduating senior schedules an interview meeting with the department chair. In this confidential interview meeting, the chair discusses with the students their responses. The gathered information serves as a valuable source of suggestions for

program improvement, as well as a source of supporting feedback on the student performance. After receiving the feedback from the students, issues of particular or repeated concern are brought to the MET faculty for further discussion and possible action.

Expected Level of Attainment of the Student Outcomes

The expected level of attainment of the student outcomes is considered using the same 4-point scale used for the individual assessment tools.

4 = Excellent

3 = Good

2 = Satisfactory

1 = Low

0 = Negligible

Referring to the above scale, a score of 3.0 or above is a desirable score for each student outcome (1)-(5). A score between 2.0 and 3.0 is a cause for review by the MET faculty with possible action or continued monitoring. A score lower than 2.0 would require corrective action to be taken by the MET Faculty.

**Results:**

*Student Outcome 1: An ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline.*

| SO 1. An ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline. | | | | | | |
|---|---|---|---|---|---|---|
| **Assessment Instrument** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** |
| Co-op Employer Survey | 3.12 | 3.13 | 3.47 | 3.2 | 3.75 | 3.15 |
| Faculty Course Assessment Reports | | | | | 3.40 | 3.88 |
| Course Term Project External Evaluation | | | | | 3.63 | 3.79 |
| Course-embedded Assessment | | | | | 3.44 | 3.49 |
| Senior Design Project (External) | | | | | 3.56 | 3.63 |
| Senior Design Project (Internal) | | | | | | 3.42 |
| Senior Exit Survey | | | | | 3.54 | 3.74 |
| Alumni Survey | | | | | 2.69 | |

Assessment Data (Level of Attainment): 4 = Excellent; 3 = Good; 2 = Satisfactory; 1 = Low; 0 = Negligible

*Student Outcome 2: An ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline;*

| SO 2. An ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline. | | | |
|---|---|---|---|
| **Assessment Instrument** | **Fall 2019** | **Spring 2020** | **2020-21** |
| Faculty Course Assessment Reports | 3.29 | 3.29 | 3.41 |
| Course Term Project External Evaluation | 3.45 | 3.79 | 3.74 |
| Course-embedded Assessment | 3.12 | 3.39 | 3.40 |
| Senior Design Project (External) | 3.37 | 3.45 | 3.68 |
| Senior Design Project (Internal) | | | 3.23 |
| Senior Exit Survey | | 3.09 | 3.58 |
| Alumni Survey | | 2.39 | |

Assessment Data (Level of Attainment): 4 = Excellent; 3 = Good; 2 = Satisfactory; 1 = Low; 0 = Negligible

*Student Outcome 3: An ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to locate and apply appropriate technical literature.*

| SO 3. An ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to locate and apply appropriate technical literature. | | | | | | |
|---|---|---|---|---|---|---|
| **Assessment Instrument** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** |
| Co-op Employer Survey | 3.12 | 3.13 | 2.67 | 3.30 | 3.00 | 3.05 |
| Faculty Course Assessment Reports | | | | | 3.39 | 3.41 |
| Course Term Project External Evaluation | | | | | 3.49 | 3.73 |
| Course-embedded Assessment | | | | | 3.58 | 3.65 |
| Senior Design Project (External) | | | | | 3.34 | 3.52 |
| Senior Exit Survey (Internal) | | | | | | 3.5 |
| Alumni Survey | | | | | 2.62 | |

Assessment Data (Level of Attainment): 4 = Excellent; 3 = Good; 2 = Satisfactory; 1 = Low; 0 = Negligible

*Student Outcome 4: An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes.*

| SO 4. An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes. | | | |
|---|---|---|---|
| **Assessment Instrument** | **Fall 2019** | **Spring 2020** | **2020-21** |
| Faculty Course Assessment Reports | 3.0 | 3.0 | 3.5 |
| Course-embedded Assessment | 3.29 | 3.14 | 3.06 |
| Senior Design Project (External) | 3.27 | 3.35 | 3.63 |
| Senior Design Project (Internal) | | | 3.15 |
| Senior Exit Survey | | 2.72 | 3.61 |
| Alumni Survey | | 2.77 | |

Assessment Data (Level of Attainment): 4 = Excellent; 3 = Good; 2 = Satisfactory; 1 = Low; 0 = Negligible

*Student Outcome 5: An ability to function effectively as a member as well as a leader on cross-functional teams toward a common goal.*

| SO 5. An ability to function effectively as a member as well as a leader on cross-functional teams toward a common goal. | | | | | | |
|---|---|---|---|---|---|---|
| **Assessment Instrument** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** |
| Co-op Employer Survey | 3.4 | 3.73 | 3.47 | 3.76 | 3.38 | 3.4 |
| Faculty Course Assessment Reports | | | | | 3.67 | 3.92 |
| Course Term Project External Evaluation | | | | | 3.61 | 3.79 |
| Course-embedded Assessment | | | | | 3.75 | 3.46 |
| Senior Design Project (External) | | | | | 3.45 | 3.63 |
| Senior Design Project (Internal) | | | | | | 3.28 |
| Senior Exit Survey | | | | | 3.45 | 3.82 |
| Alumni Survey | | | | | 2.62 | |

Assessment Data (Level of Attainment): 4 = Excellent; 3 = Good; 2 = Satisfactory; 1 = Low; 0 = Negligible

**Modifications for Continuous Improvement**

*Student Outcome 1: An ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline.*

In the retreat meeting of the assessment committee held on January 14, 2021, the faculty reviewed the highlighted data and discussed possible improvements. Because of previous improvement decisions, the faculty decided to continue monitoring. Actions taken to improve students' abilities to apply modern tools as specified in SO1 are listed in the table below. Although the Alumni Survey will not be administered again until 2023, results from other measures are provided if directly related to the specific improvement.

Action Items Taken to Improve SO1 in Fall 2020 and Spring 2021.

| Time Frame for Action | Actions Taken | Person Responsible | Results of Changes (2020-21 in Comparison to 2019-20) | Action Status |
|---|---|---|---|---|
| 2020-2021 | MET4250 Applied Mechatronics: Machine vision (e.g., high dynamic range imaging techniques for welding process) and machine learning (e.g., supervised learning) concepts and technologies were incorporated in the course materials. Students learned the latest tools, concepts, and techniques. They presented their understanding and findings by applying the tools, concepts, and techniques into the real-world applications, such as welding and additive manufacturing. | Duckbong Kim | MET 4250 FCAR SO1 result remained the same at 3.50. | Completed |
| 2020-2021 | MET4220 Industrial Automation and Robotics: Two industrial robots (Fanuc ArcMate 120iC), donated by Unipres USA, were installed in the MET machine shop, offering more hands-on experience to students. Students can apply the on/off-line robot programs to welding and additive manufacturing processes. | Duckbong Kim | The MET 4220 FCAR SO1 result remained stable at 3.67. | Completed |

*Student Outcome 2: An ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline;*

In the retreat meeting of the assessment committee held on January 14, 2021, the faculty reviewed the highlighted data and discussed possible improvements. As shown in the table below, improvements were implemented in AY 2020-21. Although the Alumni Survey will not be administered again until 2023, results from other measures are cited, if relevant to the specific improvement action taken.

Action Items Taken to Improve SO2 in Fall 2020 and Spring 2021.

| Time Frame for Action | Actions Taken | Person Responsible | Results of Change (2020-21 in Comparison to 2019-20) | Action Status |
|---|---|---|---|---|
| 2019-2020 and 2020-2021 | MET3301 CAD for Technology was a 2-credit course. In Spring 2020, the faculty revised the curriculum to change the course to MET3303, a 3-credit course to improve students' design skills. | MET Faculty | The MET 3301 FCAR SO2 result in Fall 2019 was 3.00. The MET 3303 FCAR result in Fall 2020 was 3.00. | Completed.<br><br>MET 3303 was offered in Fall 2020. |
| 2020-2021 | MET3303: SolidWorks was incorporated to increase 3D design experience, using solid modeling, innovation, and techno-entrepreneurship skills. | Ismail Fidan | | In-progress: At the retreat meetings on May 14-21, 2021, faculty decided that more implementation will continue in AY2021-2022. |
| 2020-2021 | MET3060 Computer Numerical Control Machining: Fusion 360 was incorporated to increase the students' CAD/ CAM experiences. Students teams were tasked to design and improve the TTU Foundry and iMakerSpace. | Ismail Fidan | | In-progress: At the retreat meetings on May 14-21, 2021, faculty decided that more implementation will continue in AY2021-2022. |

*Student Outcome 3: An ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to locate and apply appropriate technical literature.*

Since no specific issues related to SO3 were identified, the faculty focused on general improvements for SO3. As shown in the table below, improvement actions were taken in AY 2020-21. Although the Alumni Survey will not be administered again until 2023, results from other measures are cited, if relevant to the specific improvement action taken.

Action Items Taken to Improve SO3 in Fall 2020 and Spring 2021.

| Time Frame for Action | Actions Taken | Person Responsible | Results of Changes (2020-21 in Comparison to 2019-20) | Action Status |
|---|---|---|---|---|
| 2020-2021 (Spring 2021) | MET students worked with English Department graduate assistant assigned to the College of Engineering (Ms. Sarah Moore) to improve their technical communication and writing skills, especially for MET4620 Senior Projects. | Josh Qualls previously, now Mike Baswell | | In-process: At meetings on May 14-21, 2021, the faculty decided that more implementation will occur in AY2021-2022. |
| 2020-2021 | Topics were given to the students in MET 1100 to perform preliminary research and write a report with the findings. A list of guidelines was also provided to the students for reference. In MET 3403 and MET 3303, students were required to work on computer software such as Solidworks and AutoCAD, and to submit reports with technical analysis. | Venkata Avinash Paruchuri | An impact on assessment results is not expected until these students advance to their senior year. | In-process: At meetings on May 14-21, 2021, the faculty decided that more implementation will occur in AY2021-2022. |

*Student Outcome 4: An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes.*

In the retreat meeting of the assessment committee held in January 2021, the faculty reviewed the highlighted data through Fall 2020 and discussed possible improvements. The improvements were addressed by new equipment and assignments in a new course (MET4550 Maintenance, Replacement, and Reliability Engineering). The table below shows the improvement actions that have been made in AY 2020-21. Although the Alumni Survey will not be administered again until Spring 2023, results from other measures are cited, if relevant to the specific improvement action taken.

Action Items Taken to Improve SO4 in Fall 2020 and Spring 2021.

| Time Frame for Action | Actions Taken | Person Responsible | Results of Changes (2020-21 in Comparison to 2019-20) | Action Status |
|---|---|---|---|---|
| 2020-2021 | A portable 7-axis coordinate measuring machine (CMM), Hexagon Romer Arm 7525SIE, was installed in the MET machine shop. Students were able to compare the volumetric errors between designed and measured outcomes in terms of geometric dimensioning and tolerancing (GD&T). | Duckbong Kim | | In-progress: At the retreat meetings on May 14-21, 2021, the faculty decided that more implementation will occur in AY2021-2022. |
| 2021 | In MET 4550, the project included aspects of designing the model in Solidworks, printing the model using 3D printing, metal casting the part in foundry using 3D print as a pattern, and testing the final products for surface roughness using a profilometer. In addition, students studied various parameters that govern the quality of 3D printing and metal casting. Upon completion of the project, students analyzed the data collected during the study, and presented and submitted their findings as a report. A faculty committee with Dr. Vondra, Dr. Fidan and Dr. Paruchuri was present at these presentations to evaluate student performance. | Venkata Avinash Paruchuri | FCAR SO4 assessment results were 4.00 for this new course. | In-progress: At the retreat meetings on May 14-21, 2021, faculty decided that more implementation will occur in AY2021-2022. |

*Student Outcome 5: An ability to function effectively as a member as well as a leader on cross-functional teams toward a common goal.*

In the retreat meeting of the assessment committee held on January 14, 2021, the faculty reviewed the highlighted data and discussed possible improvements. The table below shows the improvements made in AY 2020-21. The Alumni Survey will not be administered again until Spring 2023, so assessment results relevant to the specific improvement actions are not yet available.

Action Items Taken to Improve SO5 in Fall 2020 and Spring 2021.

| Time Frame for Action | Actions Taken | Person Responsible | Results of Changes (2020-21 in Comparison to 2019-20) | Action Status |
|---|---|---|---|---|
| 2020-2021 | MET4000 Advanced Foundry Technology Assignment involved scanning an existing tool (pattern) using the Hexagon arm to incorporate solidification modeling (Altair Inspire Cast). This was being done to evaluate an existing gating design to troubleshoot potential defects. Teams created different capabilities for leadership, data collection, data analysis, and reporting. | Fred Vondra | | Completed |
| 2020-2021 | MET4620 Senior Project: Students learned how to manage the project tasks and deliverables in virtual team environments (e.g., Zoom, YouTube, and Teams) with respect to the COVID-19 guidelines. | Mike Baswell | | Completed |

**Appendices**

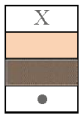
1. Curriculum Map

## Appendix 1: Curriculum Map

**Table 4.2b. Mapping of BSET Curriculum to the ETAC of ABET Student Outcomes**

| BSET Major Courses (Updated 5-14-2020) | SO 1 | SO 2 | SO 3 | SO 4 | SO 5 |
|---|---|---|---|---|---|
| MET 1100 - Intro. To Manufacturing Engineering Tech. | X | X | X | | |
| MET 2000 - Occupational Safety | X | X | X | X | |
| MET 2065 - Metal Manufacturing Technology | X | X | | | |
| MET 2310* - Applied Fluid Power | X | X | X | | |
| MET 2400 - Statics and Strength of Materials | X | X | X | X | X |
| MET 2615 - Engineering Ethics and Professionalism | X | X | X | | X |
| MET 3000 - Principles of Metal Casting | | X | | X | |
| MET 3100 - Applied Physical Metallurgy | X | X | X | X | |
| MET 3150 - Maintenance Technology 1 | X | X | X | | X |
| MET 3200 - Applied Electricity and Electronics | X | X | | | |
| MET 3301 - CAD for Technology | | X● | X● | | X● |
| MET 3403 - Applied Machine Elements | X | X | X | X | |
| MET 3700 - Manufacturing Cost Estimating | XX | X | X | X | |
| MET 3710 - Methods Design and Work Meas. | X | X | X | X | |
| MET 4310 - Plant Layout and Materials Handling | | X● | X● | | X● |
| MET 4620 - Senior Projects | X | X | X | X | X |
| Concentration I - Mechatronics Engr. Tech. 15 cr. | | | | | |
| MET 3060 - CNC Machining Practices (required) | X● | X● | X● | | X● |
| MET 3260 - Industrial Electronics (required) | X | X | X | | X |
| MET 4250 - Applied Mechatronics (required) | X | X | X | | |
| MET 4000** - Advanced Foundry (elective) | X | X | X | | X |
| MET 4210** - Programmable Logic Controllers (elective) | X | X | X | | |
| MET 4220 - Ind. Automation and Robotics (elective) | X | X | X | | |
| Concentration II - Engr. Tech. Mgmt. 15 cr. | | | | | |
| MET 4650 - Lean Six Sigma Mfg. (required) | X | X | X | X | |
| Select 4 courses from MET and Business elective courses | | | | | |

*MET 2310 - Applied Fluid Power will not be offered any more from Fall 2020.
**MET 4000 - Advanced Foundry will be offered in Fall 2020.
**MET 4210 – Programmable Logic Controllers will be offered in Fall 2020.



X Courses address the student outcomes
Courses used for the FCAR
Courses used for Course-embedded Assessment
● Courses used for Course Term Project External Evaluation