Mechanical Engineering (ME) Baccalaureate Degree

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ACADEMIC YEAR COVERED BY THIS REPORT: 2021-2022

I. PROGRAM LEARNING OUTCOMES

The Mechanical Engineering program has adopted the Student Outcomes (SO) listed below 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. These outcomes are identical to those listed in Criterion 3 of the ABET criteria for accreditation of engineering programs. No additional outcomes have been developed for the program.

II. PROCEDURES USED FOR ASSESSMENT

A. Direct Assessment

Summary of Student Outcome Assessment Cycles, 2018-2020 and 2020-2022 (Taken from attached internal ABET Criterion 4 document, which includes properly formatted figures and tables). Because the Mechanical Engineering degree program is offered at both the Main Campus and the Lake Campus, student outcomes were assessed at both campuses. The Main Campus courses selected for assessment the 2018-2020 and 2020-2022 cycles are shown in Table 4-1a, which also shows the specific student outcomes that were assessed in each course. Based on their

breadth of ABET (1)-(7) outcomes, it is evident that the design courses ME 1040 in the first-year and ME 4910-4920 (Senior Capstone) are especially critical to assess, and are consequently included in each 2-year assessment cycle. The engineering mechanics courses ME 2120 and ME 3120 represent a critical part of the prerequisite pathway to upper division courses, and are thus also assessed in each 2-year cycle. The ME 2210 and ME 2700 courses were also chosen as important parts of the prerequisite pathway, although the CQI committee does not consider it crucial to assess these courses during each 2-year assessment cycle. Laboratory courses, including ME 3600 and ME 4620, were also chosen in order to ensure continuous improvement of laboratory skills and associated hands-on learning. Table 4-1a. ME student outcome 2-year assessment cycles, Main Campus MAIN CAMPUS 2 YEAR CYCLES Prerequisites (1) (2) (3) (4) (5) (6) (7) Coordinator YEAR 1 (2018-2019) (Add) (Add) ME 1040 (4 pts, 4 project) x x x x ME 2120 (1 point, final) x ME 2210 (1 point, final) x ME 3120 (2 points, 2 final) x ME 4910 (7 points, 7 report) x x x x x x YEAR 2 (2019-2020) ME 3600 (6 points, 6 reports) x x x x ME 4620 (5 points, 5 reports) x x ME 4920 (18 points, 18 report) x x x x x x YEAR 1 (2020-2021) ME 1040 (6 points,6 project) x x x x ME 2120 (8 points, 8 exam) x ME 2700 (3 points, 3 exam) x ME 3120 (12 points, 12 exam) x YEAR 2 (2021-2022) ME 4620 (10 points, 2 exam, 8 lab) x x ME 4910 (6 points, 6 report) x x x x x x ME 4920 (6 points, 6 report) x x x x x x In order to ensure the fulfillment of ABET (1)-(7) outcomes at the Lake Campus, as well as the continuity and quality of the ME program across both campuses, assessment at the Lake Campus has included ALL required ME courses (Table 4-1b). In addition to the courses chosen for assessment at the Main Campus, these also included the first-year programming course ME 1020, as well as the entire thermal-fluid sequence ME 3310, ME 3350 and ME 3360. However, the initiation of assessment at Lake Campus was delayed until year 2 of the first cycle (2019-2020), which resulted in a substantially larger number of courses assessed that year. It should finally be noted that in year 2 of the second cycle, the Lake Campus data for ME 4620 was unable to be collected. The instructor for that section of the course left the institution and did not provide access to the course materials required for this assessment. However, even without this particular course, all 7 student outcomes were assessed at the Lake Campus during the 2020-2022 cycle. Moreover, the Lake Campus student outcomes for ME 4620 were successfully assessed during the prior 2018-2020 cycle. Table 4-1b. ME student outcome 2-year assessment cycles, Lake Campus LAKE CAMPUS 2 YEAR CYCLES Prerequisites (1) (2) (3) (4) (5) (6) (7) Coordinator YEAR 2 (2019-2020) (Add) (Add) ME 1020 (2 points, 2 homework) 2 ME 1040 (2 points, 2 final) x ME 2120 (2 points, 2 final) x ME 2700 (2 points, 2 final) x ME 3310 (2 points, 2 exam) x ME 3350 (2 points, 2 final) x ME 3360 (2 points, 2 exam) x ME 3600 (2 points, 2 final) x ME 4620 (3 points, 3 lab) x x ME 4920 (9 points, 1 exrcz, 9 report) x x x x x x YEAR 1 (2020-2021) ME 1040 (6 points, 6 project) x x x x ME 2120 (8 points, 8 project) x ME 2700 (6 points, 6 exam) x ME 3120 (12 points, 6 exam, 6 HW) x YEAR 2 (2021-2022) ME 4620 (not collected, inst. Issue) x x ME 4910 (6 points, 6 report) x x x x x x ME 4920 (6 points, 6 report) x x x x x x At the end of the 2-year assessment cycle taking place during 2020-2021 and 2021-2022 academic, a comprehensive review of the collected assessment was completed by compiling data from all 4 semesters. While all (1)-(7) Student Outcomes were covered during this period, each outcome was not covered with equal frequency. Outcomes (1), (2), (3), (4), (6) and (7) were consistently assessed, (5) was

primarily assessed through Capstone Design and thus less frequently. The total number of assessments broken down by (1)-(7) is shown in Table 4-4, and a sample of the distilled data is shown in Table 4-5. All detailed assessment data is available upon request. Table 4-5. Number of assessment data points broken down by ABET student outcome for 2020-2022. MAIN CAMPUS Student Outcome Number of Assessments 1 23 2 6 3 10 4 4 5 2 6 4 7 5 LAKE CAMPUS Student Outcome Number of Assessments 1 26 2 6 3 4 4 4 5 2 6 2 7 3 Table 4-5. Examples of summarized student outcome assessment for 2020-2022. Class Exam/Project Question Outcome % O. % S. % A. % D. % N.I. % >A. ME 1040 (F20) Bridge project Decision matrix 2,4 14 2 0 0 6 72.7 ME 1040 (F20) Bridge project Ethics discussion 4 15 1 1 0 5 72.7 ME 2120 (F20) Exam 1 Wire tensioning 1 0 1 0 0 0 100 ME 2120 (F20) Exam 2 Center of Mass 1 17 4 8 0 0 100 ME 2700 (S21) Final Exam Phase diagrams 1 10 0 0 1 3 71.4 ME 3120 (F20) Exam 1 Composite thermal stresses 1 12 0 0 0 28 30 ME 3120 (S21) Final Exam Thin walled vessels 1,2 13 0 0 0 1 92.8 ME 4620 (F21) Fatigue Lab Engineering report format 3 7 13 0 0 0 100 ME 4620 (F21) Weibull Lab Technical explanations 3 0 7 7 0 6 70 ME 4910 (F21) Capstone Report Proper citation usage 7 34 0 0 0 0 100 ME 4910 (F21) Team Pres. Public presentation skills 3 26 8 0 0 0 100 ME 4920 (S22) Capstone Report Proper Gantt chart usage 5 10 20 0 0 4 88.2 ME 4920 (S22) Capstone Report Data interpretation 6 34 0 0 0 0 100 ME 4920 (S22) Capstone Report Design to specific needs 2 34 0 0 0 0 100 ME 4910 (F21) Report (LAKE) Design to specific needs 2 13 8 0 0 0 100 ME 4910 (F21) Team Pres. Public presentation skills 21 0 0 0 0 0 100 ME 4920 (S22) Capstone Report Societal impact 4 5 0 4 12 0 42.8 ME 4920 (S22) Capstone Report Data interpretation 21 0 0 0 0 0 100 ME 3120 (F20) Final (LAKE) Loaded cantilevers 1 15 0 0 0 5 75 ME 2120 (F20) Exam 1 (LAKE) Moments in 3-space 1 6 8 2 3 1 80

B. Scoring of Student Work

Each instructor for an assessed class was asked to record student performance on each exam problem. At the end of the semester, the instructor reported individualized performance on each exam problem, in addition to the exam problems themselves, to the ABET committee for assessment. Each exam question was individually mapped to Student Outcomes (1)-(7), and assessed according to the following rubric 95% to 100% was considered Outstanding, 80% to 95% was considered Strong, 70% to 80% was considered Acceptable, 60% to 70% was considered Developing, and less than 60% was considered Needs Improvement. As needed, instructors of assessed classes were also requested to submit lab reports and project reports as well. While these assessments show far less variance, they can be important to provide a full assessment of Student Outcomes (1)-(7). On an individual basis, some instructors voluntarily assigned lab and project grades using rubrics of their own. For example, some instructors for ME 4620 (Mechanical Testing Lab) use a rubric for grading technical performance, report formatting, timeliness and analysis quality for each individual lab report. In the case where instructors were not using a suitable rubric for their grading, CQI committee members did the analysis of the reports using an appropriate rubric. The result of this assessment was a relatively large number of quantitative data sets, consisting of individual Student Outcome assessments based on exams, lab reports and project reports. Each data set represented an

entire class performance on an individual task that was mapped to Student Outcomes (1)-(2) (sometimes more than one S.O.). Each data set was assessed according to the following threshold 70% of the class should be performing at Outstanding, Strong, or Acceptable levels.

C. Indirect Assessment

Qualitative Student Outcome Assessment Design – Exit Interviews In addition to the quantitative assessment process described above, there are several qualitative assessment processes that occur in the ME undergraduate program that should be mentioned. In the past, senior exit interviews have been an important source of feedback and program assessment. Historically, the Academic Programming Director (Ms. Heather Casto) performed these interviews in person. Recently, the exit interviews have been performed as an online survey. While the specific format of the exit interviews has changed over the years, the feedback provided by graduating seniors has been found to be an excellent source of qualitative assessment. In fact, senior exit interviews often catch programmatic issues well before any other source of assessment, allowing quick adjustment of instructor, course formatting and programmatic elements as needed to maintain and improve the program. While a formal analysis of exit interviews is not presented here, the data from the past 6 years of senior exit interviews is available upon request. Example of Exit Interview Questions The content of the exit interview can slightly change over time, but maintains the consistent goal of being an effective query of the graduating students on their overall experience in the program and their perceptions of strengths and weaknesses of the program. The current exit interview consists of the following questions 1. Looking back on your time here in the MME department here at WSU, what are some of the highlights? 2. Please describe any difficulty with courses, professors, or employment during your time in the MME department. For each, how could we improve our response to your request for assistance (tutoring, faculty support, etc)? 3. If you could give a faculty member an award, who and why? 4. What course did you learn the most from? What was special about this course? 5. What course has the most room for improvement and what improvements are necessary? 6. Are there any courses you would like to see offered that aren't currently being offered? 7. What course had the most room for improvement and what improvements are necessary? 8. Of the professors you took classes with in the MME Department, which professor had the most positive impact on you? 9. How could you have been better supported in terms of advising, tutoring, counseling, etc.? 10. What improvements in MME office operations should be made in areas such as scheduling appointments, senior design reimbursements, pre-req questions/issues, etc.? 11. If you could give a staff member an award, who and why? 12. What can be done to improve experiences in laboratories? 13. What areas of our facilities can be improved upon? 14. Did you participate in an Internship or Co-op? a. When? b. With who (list all)? c. What do you feel you gained from this experience? d. Did you visit or use resources provided by the BCDC? If so, please list and describe your assessment of the services. 15. Do you believe our curriculum prepared you for graduate school and /or a career in mechanical or materials engineering. Please explain. If no, what could we do to better prepare you for grad

school/career? 16. What are your career goals? 17. Have you received any job offer? If so, with who? 18. What is your overall impression of the Department of Mechanical and Materials Engineering Department? 19. Would you recommend us to your peers? If not, what do we need to do better? 20. Is there anything else you would like to add that was not mentioned? 21. How would you rate your overall experience with your academic advisor (1-5 rating) 22. Please provide any comments or concerns related to advising Added to the Spring 2020 and subsequent exit interviews to address more widespread transition to remote and online learning following COVID-19 23. Which of the following ways did your instructors use to communicate new materials to you a. Synchronous delivery Lectures were broadcast live b. Asynchronous delivery Lectures were recorded and made available to you on Pilot 24. How did you interact with your instructor? Choose all that apply. a. During a live class using the chat box in BB Collaborate (Pilot) b. During a live class using the chat box in WebEx c. Using phone or email d. During office hours using BB Collaborate e. During office hours using WebEx f. Did not interact with the instructor 25. Did you have a study group that met regularly using WebEx, BB Collaborate, Zoom, or other online medium? (Yes or No) 26. How did you interact with your classmates? a. Using WebEx, BB collaborate, or other online medium b. Using phone or email c. Did not interact with classmates 27. In the space below, please comment on your best experience during remote learning 28. In the space below, please comment on your worst experience during remote learning

III. ASSESSMENT RESULTS/INFORMATION:

The data from the qualitative and quantitative Student Outcome assessments is used in a closed-loop process of review and program improvement as shown in Figure 4-3 of the attached report. At the end of each assessment cycle, the CQI committee and department chair conduct a formal review of the quantitative and qualitative Student Outcome data. The results of this review are a series of observations and recommendations for program improvement, which is presented to the department chair, course coordinators and faculty, as appropriate. A significant amount of deliberation is required by the CQI committee as the quantitative assessment results are translated into recommendations for action. During the evaluation of assessment data, all results that fell below the 70% Acceptable threshold were individually considered. Upon inspection of the data, it is evident that student performance on exams is highly dependent on the difficulty level of the specific exam question. For example, some questions on exams are specifically designed as "challenge" questions by the instructor. For this type of exam question, the ABET committee generally determined that performance below the 70% Acceptable threshold was not a cause for concern. On the other hand, consistent sub-70% performance across multiple assessment data sets in a single topic area was considered problematic. The results and recommendations are presented to the Curriculum committee for further evaluation and/or modification, which then pass them on to program faculty and course coordinators as appropriate. For example, a recommendation for small adjustments to an individual course can be presented to the course coordinator and implemented without much difficulty. Larger changes, such as the addition of a new class or a prerequisite structure change, required full faculty approval.

These types of change are presented and discussed in departmental meeting and faculty retreats. The results of the changes are then monitored in the next assessment cycle. Note that the order of recommendation presentation can vary depending on meeting schedules. For example, if the CQI committee meet and perform their annual analysis in the middle of a semester, the resulting recommendations will be presented to the Curriculum committee before being presented at the end-of-semester departmental meeting. While this may be a procedural variability, the overall goal is to ensure that the proper faculty, administrators and committees are all aware of the changes and have the opportunity to provide input.

The CQI committee reviewed this entire data set in order to determine a set of programmatic concerns or recommendations. The committee was especially careful to review each assessment data point that was below the 70% threshold for acceptable performance. As discussed previously, not every data point below the 70% threshold was a cause for concern. For the 2020-2021 and 2021-2022 assessment years, student performance levels are shown in Figure 4-6 of the attached report, clearly indicating significant number of data points below the 70% threshold. All of these were considered by the CQI committee as possible causes for concern. As per the WSU BSME SO closed-loop assessment procedure, the CQI committee compiled a list of recommendations and charged the Curriculum committee to assess and take action. The recommendations were passed to the course coordinators for further discussion. During these discussions, it was heavily emphasized to the course coordinators that students had performed acceptably in many other assessments and that the vast majority of the assessments were of no concern. The course coordinators were invited to participate in the CQI committee discussions about any possible programmatic improvements or changes as a result of these assessments. The CQI committee identified no issues with the prerequisite structure during the 2020-2022 assessments. Out of all these assessments, only one was identified as possibly needing further attention from the chair or course coordinator. This data point is shown in Table 4-6. It should be noted that this table shows only the S.O. data point that resulted in changes to course content during the 2020-2022 assessment cycle. This table is significantly shorter than the similar table shown for the 2018-2020 assessment cycle. There are two reasons for this. The first reason is that, during this assessment cycle, the CQI committee was somewhat more selective in deciding if a sub-70% data point merited engagement with course coordinators and faculty. However, the primary reason for this relatively short list is that most of the sub-70% data points are due to course assessment methods implemented during online COVID-19 instruction, and require further assessment in a post-COVID environment. Table 4-6. Student Outcome assessment items identified as possibly requiring further concern. Course Observation and/or Recommendation ME 2120 Lake Campus (Fall 2020) 7 out of 21 students appeared to struggle in analysis of force vectors and analysis of friction blocks. A section will be added to review the characteristics of vector before introducing the force vector concept. More detailed discussions on vector addition, dot product, cross product, and mixed product will be added with plenty of examples. Homework problems for such vector operations will also be

added. As a result of the COVID-19 pandemic, many courses were run in a fully online format. Asynchronous online lecture videos were provided to students ahead of time, with the online class meet time reserved for student questions and discussion. For several large classes, ME 3120 most importantly, the online format utilized McGraw-Hill Connect for both homework and exams, with algorithmic problems requiring different numerical answers for each student. Homework was assigned regularly and credit was given only for correct numerical responses; however, the week-long timeframe and the availability of a "check-my-work" feature gave students the capability to continue reworking problems until they achieved the right answer. The exams were designed to be particularly challenging, as they were administered in a no partial credit format that included a combination of numerical and multiple-choice responses under a fixed time constraint, without the assistance of the "check-my-work" feature. The goal of this approach to online homework and exams was to develop a mastery-based learning of course material, while virtually eliminating the possibility of cheating on exams. While the no partial credit exam format resulted in a number of specific instances where 70% of the class failed to score above 70%, the overall class homework average was relatively high, suggesting that the mastery-based approach was still highly effective in supporting student learning of the course material. As an example, consider a specific data point from ME 3120, Dayton campus, Fall 2020. In regard to Exam #1, problem 3.001.a, students were required to identify the basic assumptions of torsional stress calculation in a "Check All That Apply" format with automatic scoring. In the Connect scoring model, boxes that are correctly checked are scored differently than boxes that are correctly unchecked. Likewise, boxes that are incorrectly checked are scored differently than boxes that are incorrectly unchecked. As a result, a significant number of students who missed only a single check (out of 4 possible boxes) received a score of 1.33/2.0 points, or 66.5% on this question. Thus, the only way a student could achieve greater than 70% on this question was to have all the checked and unchecked boxes correct (i.e., a score of 100%). That said, the data provided by this exam question does suggest that greater emphasis should be placed on the basic assumptions in torsion in future offerings of the course. All data and loop-closure documents are available upon request.

The CQI committee was unable to identify any general areas of concern or weakness with regards to Student Outcomes 1-7. There are small, topic-specific concerns that will be scrutinized in the future, and are being addressed through the ABET closed-loop improvement process.

IV. ACTIONS TO IMPROVE STUDENT LEARNING

The results of this assessment process are shared with the undergraduate curriculum committee on a regular basis. Areas of concern are communicated to course coordinators for possible action, and the results are fed back to CQI in a closed-loop process. The entire process is communicated to the whole faculty at least once per year during a department meeting. The chair is closely involved in this process. Results of the feedback loop for this cycle are

included in an attached document.

V. SUPPORTING DOCUMENTS

Additional documentation, when provided, is stored in the internal Academic Program Assessment of Student Learning SharePoint site.