CRITERION 4. CONTINUOUS IMPROVEMENT

A. Student Outcomes

A.1 Listing and Description of Assessment Processes

Table 4.A.1, summarizes the set of student outcome assessment methodologies and next scheduled assessment date for each outcome. A more comprehensive listing can be found in Appendix F. Assessment is performed at three levels: Introductory (I), Reinforcement (R) and Mastery (M). Mastery Level assessment takes place during the senior year of the program, and is the summative assessment for each outcome. Rubrics are used for assessment at all levels. Each rubric has a number of performance indicators that are used to rate students at one of four levels of proficiency: Exemplary, Satisfactory, Developing and Unsatisfactory. These rubrics can be found in Appendix E.1.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Assessment Methodology</th>
<th>Next Assessment</th>
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</thead>
<tbody>
<tr>
<td>(a) an ability to apply knowledge of mathematics, science, and engineering to solving problems in manufacturing engineering;</td>
<td>ENGR 214 (I) – Questions on final, quiz and homework.</td>
<td>Winter 2017</td>
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<td></td>
<td>ENGR 225 (R) – Selected Homework and Exam Questions</td>
<td>Winter 2017</td>
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<td></td>
<td>EE 352 (R) – Selected Labs, Exam Questions and Assignments</td>
<td>Spring 2017</td>
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<td></td>
<td>MFGE 465 (M) - Selected Homework/Exam Questions</td>
<td>Fall 2016</td>
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<td></td>
<td>MFGE 493 (M) – Performance on Implementation of Senior Project</td>
<td>Spring 2016</td>
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<td>(b) an ability to design and conduct experiments and to analyze and interpret data within a manufacturing context;</td>
<td>MFGE 341 (I) – Selected Lab-work/Examination Questions</td>
<td>Winter 2016</td>
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<td></td>
<td>MFGE 342 (R) – Project Work/Individual and Team Analyses</td>
<td>Winter 2016</td>
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<td></td>
<td>MFGE 454 or 434 (M) – Selected Lab-Work using DOE</td>
<td>Winter 2016</td>
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<tr>
<td>(c) an ability to design products, and to design or select the processes, equipment, tooling, and systems necessary for their manufacture to desired specifications;</td>
<td>MFGE 261 (I) – Team Design and Capstone Drawing Project</td>
<td>Spring 2017</td>
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<td></td>
<td>MFGE 362 (R) – Design Project/Select Assignments</td>
<td>Winter 2017</td>
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<td></td>
<td>MFGE 381 (R) – Design Project/Process Planning Assignments</td>
<td>Spring 2017</td>
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<td></td>
<td>MFGE 333 (R) – Design Study/Communication Requirement</td>
<td>Winter 2017</td>
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<td></td>
<td>MFGE 463 (R) – Design Project</td>
<td>Fall 2016</td>
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<tr>
<td></td>
<td>MFGE 465 (R) – Design Projects</td>
<td>Fall 2016</td>
</tr>
<tr>
<td></td>
<td>MFGE 492 (M) – Design Work in Capstone Project</td>
<td>Winter 2016</td>
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<td></td>
<td>MFGE 493 (M) – Realization of Design in Capstone Project</td>
<td>Spring 2017</td>
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<td>(d) an ability to function on multidisciplinary teams;</td>
<td>ENGR 104 (I) – Team Design Project</td>
<td>Fall 2016</td>
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<td></td>
<td>MFGE 261 (R) – Team Design Project</td>
<td>Spring 2017</td>
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<tr>
<td></td>
<td>MFGE 493 (M) – Teamwork in Capstone Design Project</td>
<td>Spring 2017</td>
</tr>
<tr>
<td>(e) an ability to identify, formulate, and solve engineering problems;</td>
<td>MFGE 342 (R) – Projects, Homework and Exam Questions</td>
<td>Winter 2017</td>
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<td></td>
<td>MFGE 493 (M) – Problem Solving in Realization of Project</td>
<td>Spring 2017</td>
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<td>(f) an understanding of professional and ethical responsibility;</td>
<td>ENGR 104 (I) – In-Class Activity/Examination Questions</td>
<td>Fall 2016</td>
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<tr>
<td></td>
<td>MFGE 381 (R) – Ethics Class Discussion/In-Class Activity</td>
<td>Spring 2017</td>
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<tr>
<td></td>
<td>MFGE 491 (M) – Ethics Assignment</td>
<td>Fall 2016</td>
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<tr>
<td></td>
<td>MFGE 493 (M) – Ethics Discussion in Project Self-Assessment</td>
<td>Spring 2017</td>
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<tr>
<td>(g) an ability to communicate effectively;</td>
<td>MFGE 261 (I) – Engineering Drawings</td>
<td>Spring 2017</td>
</tr>
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<td></td>
<td>MFGE 333 (R) – Engineering Drawings</td>
<td>Spring 2017</td>
</tr>
<tr>
<td></td>
<td>MFGE 463 (M) – Engineering Drawings</td>
<td>Fall 2016</td>
</tr>
</tbody>
</table>
Appendix F provides more of the details. This includes the following assessment and evaluation information:

- **Assessment Methodology:** The type of data collected e.g. exam questions, student project work, laboratory work, homework assignments, in-class activities etc.
- **Material Assessed:** The student work relevant to the assessment effort. Samples of these will be available for review.
- **Assessment Target:** In most cases, 80% of students receiving a Satisfactory or Exemplary rating on a performance indicator is the target.
- **Continuous Improvement Actions:** This records any actions proposed to address unsatisfactory performance for any of the performance indicators. These actions were determined at program and curriculum committee meetings for which minutes are available.
- **Re-evaluation Plan:** This identifies when the results of the improvement action will be re-evaluated. In most cases actions would be executed so that a re-evaluation can be performed at the time of the next scheduled review.

It should be noted that the information captured in these tables show student performance at all of the IRM levels of assessment and evaluation. However, the top one or two entries in each (i.e. at the Mastery level) are the summative results obtained towards the end of the program. Assessment and evaluation can consider data from more than one course at any of the levels. One important example of this is for outcome (c). The tables include information for performance across several classes at the reinforcement level. These classes develop a student’s ability to design in one or more of the areas identified by the Society of Manufacturing Engineers. 4-pillars: products (MFGE 362), processes (MFGE 333), Systems (MFGE 381), Tooling (MFGE 463) and Equipment (MFGE 465).
A.2 Frequency of Assessment Processes

Formal assessment of student outcomes (a-k) is planned to occur on a three year cycle. Appendix Tables E.5.3a and b document the planned schedule. As can be seen from these tables, there is a planned initial intense period of repeated assessment and evaluation for all outcomes at all levels around the time of the first ABET review in 2016-17. This is to assist in the refinement of the tools being developed and to practice their use. Following this, a staggered approach will be adopted where one third of the outcomes at each level are evaluated each year. As a consequence, each outcome will be evaluated at least twice within every ABET review cycle. Outcomes have been organized into three groups for this purpose: Foundations and Problem Solving (a, b, e), Professionalism and Experience (f, h, i, j) and Effectiveness in Design and Technology (c, d, g, k). Course outcomes (as distinct from a-k student outcomes) are also reviewed on a 3-year cycle as shown in Appendix Table E.5.4.

A.3 Expected Level of Attainment for Student Outcomes

The rubrics used for assessment, score students at one of four levels of proficiency for each performance indicator: Exemplary, Satisfactory, Developing and Unsatisfactory. The program has set a common level of attainment for all indicators, with the expectation that 80% of students achieve an Exemplary or Satisfactory rating. Since multiple indicators are used to assess an outcome, and attainment may be achieved in some and not in others, a blanket statement that an outcome has been met is not possible in all cases.

A.4 Summaries of Evaluation and Analysis of Attainment of Outcomes

The following are brief summaries of the tabulated assessment and evaluation information in Appendix F, for each a-k outcome. In most cases this summary focuses on summative attainment (i.e. Mastery level). The appendix contains a full record of the assessment results and evaluations completed to date at all IRM levels. Improvement actions that have been proposed as a result of these evaluations are summarized in section B.2.1 as part of this study’s discussion on continuous improvements.

a. an ability to apply knowledge of mathematics, science, and engineering to solving problems in manufacturing engineering

Mastery Level
- All five indicators assessed in MFG 493 were met.
- Indicators a.2 and a.5 where not met in MFG 465. This was also observed in some instances at the I and R levels. Evaluation by the faculty identified the need to improve student’s problem solving abilities to address the below target scores in both a.2 and a.5. It was not considered surprising that scores in a.2 mirrored performance in a.5 as the ability to create visual sketches is an integral step in problem solving.

Introductory and Reinforcement Levels
- Additional below target scores for indicators a.1, a.3 and a.4 occurred at these levels, though not at the M level. The scores for these were all within 7% points of the target. It was recommended that these indicators be monitored over the next assessments to ensure that this improvement between levels was a clear sign of improved learning.
b. an ability to design and conduct experiments and to analyze and interpret data within a manufacturing context
Mastery Level:
- In MFGE 453 assessment data for all indicators met the 80% target.
- In MFGE 434 indicator b.4 was not met. It was determined upon discussion that improvements in the manner in which requirements are stated for the assignment assessed is needed by the instructor, to better guide students towards use of researched information in forming their conclusions.

c. an ability to design products, and to design or select the processes, equipment, tooling, and systems necessary for their manufacture to desired specifications.
Mastery Level:
- In MFGE 492, assessment data for 4 of the 5 indicators met their targets.
- Indicator c.2 was slightly below the target. It was recommended that this be monitored to determine if students might be converging on a solution without using appropriate information, in some cases too quickly without adequately generating design alternatives, in other cases without doing sufficient background study and preparation to help vet the options that are available.
- In MFGE 493, assessment data for all 5 indicators met their targets.
Reinforcement Level:
- All indicators assessed in MFGE 381 and 465 met their targets.
- Targets were not met for c.2, c.3 and c.5 in MFGE 333, c.4 in 362 and c.3 in MFGE 463. Discussions revealed that in all three classes the clarity of guidelines and requirements, or the manner/timing of the assessment were factors that significantly impacted student performance, or the ability of the instructor to clearly assess the data. Instructors are to correct these during the next assessment, and to monitor for improvement.
Introductory Level:
- In MFGE 261, 4 of the 5 indicators met their targets. c.5 was slightly below and not considered a cause for action.
- In ENGR 104 assessment data for all 5 indicators met their targets.

d. an ability to function on multidisciplinary teams
Mastery Level
- All indicators satisfied the target.
- Concern was expressed that all indicators scored 100%. This suggested the need to re-examine the assessment methods and possibly the performance indicators used for this outcome.

e. an ability to identify, formulate, and solve engineering problems
Mastery Level
- All indicators satisfied the target. No recommendations were made for changes.
Introductory Level
- Assessment at this level was not performed during this period. This needs to remedied for the next cycle. Discussion with PCE faculty about a more appropriate class than
ENGR 104 where this can be assessed should be conducted. Options include ENGR 214, 225.

f. an understanding of professional and ethical responsibilities of an engineer
   
   Mastery Level:
   - Both performance indicators were met in MFGE 491, and indicator f.1 was met in MFGE 493 (f.2 was not assessed in this class).
   - No recommendations for improvement were made upon evaluation.

   g. an ability to communicate effectively
   
   Mastery Level:
   - All 4 indictors were met for MFGE 493.
   - Indicator g.3 was not met for MFGE 492. This result was skewed by penalties for incorrect submission of final proposals by some project groups. It will be monitored for improvement during the next cycle.
   - The evaluation highlighted that this rubric integrates assessment of writing, verbal and engineering drawing abilities. The faculty agreed that there should be deliberations on whether separating the assessment of these three skills, can provide more targeted improvement actions.

   Reinforcement Level:
   - Indicators g.1 and g.2 were below the target in MFGE 333. It was decided that these should be monitored to see if the improvement to the Mastery level continues for the next assessments.

h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
   
   Mastery Level:
   - Two of the three indicators were met in MFGE 491.
   - Indicator h.1 was slightly below the target.
   - Discussions focused on refinement of the assignments used for assessment and their scheduling as improvements to be made. Reduction in the number of assignments to two and using the incremental improvement between them, was agreed upon with the PCE program as improvements for the next assessment cycle.

   Reinforcement Level:
   - Assessment at this level was not performed during this period. This needs to be remedied for the next cycle. Options include MFGE 341 and 381.

i. a recognition of the need for, and an ability to engage in life-long learning
   
   Mastery Level:
   - All performance indicators were met in MFGE 492.
   - No recommendations for improvement were made upon evaluation.

   Reinforcement Level:
   - The target was not met by indicator i.1 in MFGE 333. The evaluation led to the conclusion that the wording of the indicator as interpreted by the instructor may have left the students with unclear expectations in the assignment that was assessed.
Further discussion led to a recommendation that the wording of all three indicators for this rubric be reexamined before it is applied again in the next cycle.

j. a knowledge of contemporary issues  
Mastery Level:  
• All performance indicators were met in MFGE 491.  
• No recommendations for improvement were made upon evaluation.  
Reinforcement Level  
• Assessment at these levels was not performed during this period. This needs to be remedied for the next cycle. Options include ENGR 170 at the I level, and MFGE 341 or 381 at the R level.

k. an ability to use and practical experience with the techniques, skills, and modern engineering technologies necessary for manufacturing engineering practice  
Mastery Level  
• All performance indicators were met in MFGE 493.  
• No recommendations for improvement were made upon evaluation.  
Introductory and Reinforcement Levels  
• Targets were not met for indicators k.1 and k.2 in MFGE 333. However, they were within 3%. Recommendation was to monitor to ensure that any changes narrowed or eliminated this gap.  
• Targets were not met for indicators k.1 and k.2 for MFGE 332. The assessment method needs to be improved for k.1. Students with split performance in the two assignments used for assessment were placed in the lower achievement bracket, skewing the assessment away from the target. A weighting of the assignments or use of a third would give a more accurate result. Discussion on k.2 led to the recommendation that it be examined whether or not the need for students to learn and use too many sophisticated tools, might be one reason for the poor performance in the optimization of tool paths assignment. At the same time it was felt that since this was an important ability to cultivate, consideration of rebalancing course content might be part of this examination.

A.5 Documentation and Maintenance of Results

The following mechanisms are used for documenting and maintaining the results of the outcomes assessment and evaluation process:  
(a) Outcomes Assessment Worksheets and Workbooks (see sample in Appendix E.2)  
This is the primary mechanism used for recording the results from assessment. An Excel workbook is maintained for each outcome. Within each workbook a worksheet is included for every course selected for collecting data at each of the IRM levels. Worksheets are designed around the rubrics and performance indicators that have been developed (see Appendix E.1). These are available for use by the instructors teaching a course for which assessment is being conducted. Instructors are required to document the assessment method used and to indicate the number of students attaining each level of achievement. A new workbook is created for each assessment cycle.
Program Outcomes Assessment and Evaluation Summary Tables (Appendix E.3 and Appendix F)

These tables summarize the information contained in the Outcomes Assessment Workbooks, and summaries of the evaluation performed and improvement actions recommended as originally documented in program meeting minutes. Information on the assessment process or methodology, material assessed, targets and assessment results, continuous improvement actions and the re-evaluation plan is provided.

MFGE Program Meeting Minutes (sample in Appendix H.1)

Deliberations on the evaluation of assessment data and continuous improvement actions are currently recorded primarily in the MFGE program’s meeting minutes. These are then transcribed into other documentation as needed. For example, the Continuous Improvement Actions recorded in the Program Outcomes Assessment and Evaluation Summary Tables (b) are taken directly from the program meeting minutes.

Course Outcomes 3-Year Reviews (sample in Appendix E.4)

These record attainment of course level outcomes performed by the instructor every three years. Though not directly the a-k program outcomes, they indirectly support the attainment of these. The instructor is required to report to the program (or the ENGD curriculum committee) on the following questions:

- Did students entering the class show deficiencies in the pre-requisite outcomes, and what is the evidence?
- Is the course meeting its learning outcomes, and what is the evidence?
- If learning outcomes are not being met, what changes are recommended to improve student learning?
- Are there other changes that are recommended to be made to the course and/or its learning outcomes, and if so, why?

It is the responsibility of the Program Director to maintain the documentation and data generated by the assessment process. A shared network drive has been created for instructors to deposit assessment data when it is collected. The director organizes this data and extracts and summarizes what is needed to create the required summaries. Collection and maintenance of meeting minutes is also their responsibility.

B. Continuous Improvement

B.1 The Continuous Improvement Process

The continuous improvement process used to regularly assess student outcomes is shown in Figure 4.1. The inputs to the process (top of figure) are the published student outcomes, program educational objectives and course specifications (defining the course content and course learning outcomes). A mapping matrix relates the program level student outcomes to each of the courses (see Appendix E, Table E.5.2). This matrix also stipulates which courses are used for assessing attainment of student outcomes at the Introductory, Reinforcement and Mastery (IRM) levels, and the lead faculty in each case. This matrix is discussed in more detail in Criterion 5.

1. Course Level Evaluation: