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Using Lean Principles to Improve an Engineering Technology Assessment Process

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Introduction

A commitment to quality engineering technology education requires a well-defined process of continuous improvement, as well as a commitment to maintenance and management of that plan. According to Juran [1], managing for quality requires three components:

1. **Planning** - to determine and understand who the customers are and how to respond to their needs with appropriate processes.
2. **Control** - to evaluate how well the processes are meeting those needs, as well as providing feedback to all constituents
3. **Improvement** - to maintain and further improve the quality.

In addition, maintenance of ABET accreditation requires a commitment to continuous improvement. The Criteria for Accrediting Engineering Technology Programs [2] states in Criterion 4:

> "The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program."

In support of the "planning" [1] component of quality program management, and to continue to attract students, provide qualified graduates to industrial constituents, maintain ABET accreditation, as well as support the university mission, the Mechanical Engineering Technology (MET) program at Montana State University (MSU) maintains a Continuous Quality Improvement (CQI) Plan. This plan contains the following components:

- Program Goals
- Program Mission
- Program Educational Objectives
- Program Student Educational Outcomes – mapped to ABET a through k outcomes
- Program Core Competencies
- MET Course Outcomes
- Process for Curriculum Development
- Processes for Program Assessment

Each of the components are important, and require maintenance activity, or "control" [1] to understand how well they are working in support of program quality. A robust continuous improvement program also involves periodic review or "self-assessment" of the processes used to quantify and qualify program success. Activities and events that provide input for this review are:

- Input from program constituents (students, industry, etc.)
- Technological innovations requiring integration of new technical content in courses
- Input from the university strategic planning process
- Yearly ABET accreditation changes
- Lessons learned from past ABET visits

The MET program at MSU is uniquely part of the Mechanical & Industrial Engineering (M&IE) Department, which also houses a Mechanical Engineering (ME) and Industrial & Managements Systems Engineering (IMSE) program. Because our programs (MET, ME, and IMSE) share courses, facilities, and faculty, our assessment processes are understandably linked, integrated, and shared. While our MET program is accredited by the Engineering Technology Accreditation Commission [2], recent approved changes to the Engineering Accreditation Commission Criteria 3 - Student Outcomes in the 2018-2019 Criteria for Accreditation Engineering Programs [3], generated a requirement for our ME and IMSE programs to revise their student learning outcomes and related assessment tools. To maintain the department level integrated assessment activity as much as possible, these changes prompted a review of our MET CQI Plan and related assessment activity as well.

In addition, at the conclusion of our most recent TAC of ABET accreditation visit, our faculty reflected on the activities completed to prepare for the visit, as well as reviewed the input generated by the evaluators during and after the visit. As a result, the following "lessons learned" list was generated:

- Self-Study preparation time was cumbersome and excessive
- Review documentation preparation impacted productivity of professors
- The overall amount of data collected was excessive and seemed to be there "just-in-case"
- Linkage of data to assessment of specific outcomes was difficult to communicate
- Process did not effectively and adequately address all outcomes
- Processes for assessment were vague and data collection tools not well defined
- Assessment activity was inefficient and inconsistent

These lessons, along with the self-assessment input, encouraged a review the current activity performed in support of our assessment plans. Our goal was to simplify, as much as possible, while providing more value-added assessment data for consideration when reviewing program quality. This goal aligned well with the fundamental principle of Lean Manufacturing, which is to reduce or eliminate waste in all functions. This paper will outline and summarize the activities completed, the results attained, and the future work identified as our processes were reviewed and improved using Lean principles.

Why use Lean Principles?

The fundamental principle of Lean is to reduce or eliminate waste. Most sources attribute the evolution of Lean Principles from Lean Manufacturing. Lean Manufacturing evolved from the

Toyota Production System [9], which was concerned with production in a waste-free environment. According to SAE International [4], “The use of the term "Lean", in a business or manufacturing environment, describes a philosophy that incorporates a collection of tools and techniques into the business processes to optimize time, human resources, assets, and productivity, while improving the quality level of products and services to their customers. Becoming "Lean" is a commitment to a process and a tremendous learning experience should you attempt to implement Lean principles and practices into your organization.” Lean principles have also been implemented in educational settings in the past. According to Ziskovsky [5], “Lean is a dynamic and authentic continuous improvement process. It promotes a constant state of re-evaluation that asks; Can this be done in a better way or with a better outcome? What can be eliminated in the process without reducing value to the customer/end-user? Lean is proactive rather than reactive. It seeks to anticipate and prevent rather than fix and resolve.” To improve our assessment activity, we decided to practice the same fundamentals that have benefitted manufacturing, educational, service, health care industries, construction, etc., improve and function more efficiently. Thus, a complete revamping of our current continuous improvement processes and activities was undertaken using Lean principles.

Process for Improvement of Assessment Activity

The fundamental core philosophy to embrace when implementing a Lean improvement activity is to focus on what is valuable to the customer, and to eliminate all waste associated with the activities and processes used to develop that customer value. The basic method chosen to improve our assessment activity is outlined in the text “Learning to See” by Rother and Shook [6]. In general, this process involves the following steps:

1. Identify the current-state of continuous improvement and assessment activity
2. Evaluate the current-state to find value
3. Develop the future-state map – eliminating wasted activity
4. Achieve / Implement the future state

This method targets all activities associated with program quality and ultimately leads to the best value-added path to success.

Quality Improvement Program Review – the Overall Current State

As previously stated, our program improvement activities are guided by a documented CQI Plan. The stated goals of this plan are for the MET Program at MSU to:

- Support the mission and vision of the University (MSU), College of Engineering (COE), department of Mechanical and Industrial Engineering (M&IE) and Mechanical Engineering Technology (MET) Program.
- Prepare students for successful MET careers which suit our program constituents.
- Maintain ABET-ETAC accreditation.
- Define the MET program mission, educational objectives, and educational outcomes, define assessment tools and evaluation criteria, and mandate change when appropriate and necessary.

- Be staffed with qualified faculty, and, support continuous professional development.
- Receive adequate budgetary support for laboratory and teaching equipment, computer access and software, appropriate faculty development, and other reasonable and necessary needs.
- Be administered by supportive and qualified administrators.
- Maintain access to library and other reference materials, computers and computer software, laboratory and shop facilities as necessary to support the educational process.
- Continually assess the impact of University, College, and Departmental requirements such as the University Core Curriculum, service courses both inside and outside the College, and graduation verification procedures for the program.
- Provide opportunities for MET students to grow professionally through involvement in appropriate professional societies (such as ASME, SAE and ASHRAE, SWE, etc.).

As this plan was reviewed to clarify the current state of our program assessment activity, it became apparent that we divide our focus into two areas - overall program quality, as well as assessment of how well our students meet program student outcomes. This seemingly simple revelation provided clarity for our path forward, thus allowing us to more effectively separate and define important program outcomes assessment activities.

Improvement Step 1 – Identification of Current-State of the MET Assessment Process

The CQI plan includes a description of the process used for assessment. It defines the schedule and responsibility for collection and evaluation of data as it currently exists [7]. The basic process (figure 1) includes data collection, data summarization, review and evaluation of the summary data, planning of improvement activity, and documentation of results.

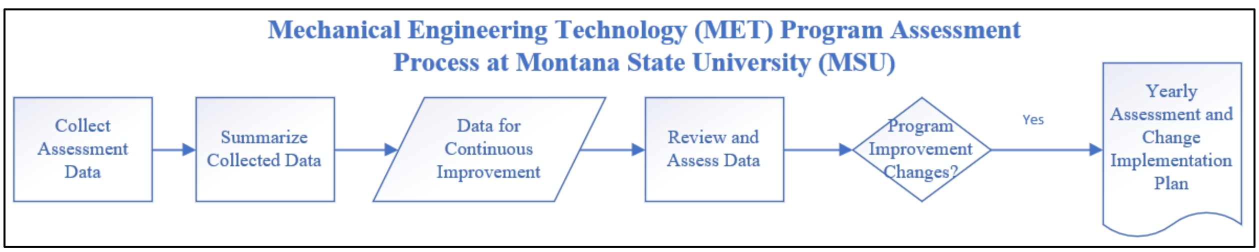

Figure 1. Current State Assessment Process Flowchart

Several tools are utilized to collect assessment data. In addition to providing information related to overall program quality, these tools are used to assess and evaluate how well program educational outcomes are being met by our graduates. Ultimately, a through k outcomes identified by ABET [2] must be appropriately assessed. Table 1 provides an overview of the tools and activities currently utilized for data collection.

Table 1: Data Collection Tools – Current State

Tool / Instrument	Metric	Scale
Student Interviews	• Students are interviewed by a faculty member or department head and asked to rate their level of attainment of each of the MET program outcomes. • Students are also asked to answer additional open-ended questions to provide program feedback to the faculty.	Quantitative rating scale of 1-5 Qualitative assessment of answers provided Qualitative assessment of answers provided
Industrial Advisory Board (IAB)	• The board reviews selected Capstone Projects • The board reviews elements of each academic program and provides "Commendations and Recommendations"	Quantitative rating scale of 1-5 Qualitative assessment of answers provided
Employer Surveys	• % of MET graduates answering survey questions positively	Quantitative rating scale of 1-5 Qualitative assessment of answers provided
Alumni Surveys	• % of MET graduates answering survey questions positively	Quantitative rating scale of 1-5 Qualitative assessment of answers provided
Faculty Discussions	• Weekly program issues discussion • Annual program curriculum review • Annual facilities review	Qualitative assessment
Capstone Reviews	• Faculty review of Capstone I reports and presentations • Sponsor review of Capstone I reports and presentations • Faculty, IAB and Sponsor review of Capstone II Design Presentation (Design Fair)	Quantitative rating scale (various scales) Qualitative assessment
FE Exam	• All students take nationally normed Fundamentals of Engineering (FE) Exam.	Quantitative comparison of pass rate to national average
Placement	• Placement data provides view of the job functions that our graduates are moving into. Also provides measure of placement rate.	Quantitative assessment of placement rate. Goal = 85%
Student Internships	• Supervisor evaluation of intern.	Quantitative rating scale 1-5

As stated in our CQI Plan [7] "Ultimately, all information and assessment data are reviewed and evaluated collectively, and an assessment made. Using the data from the assessment tools, an overall assessment regarding the level to which outcomes are being achieved can be determined. Quantifiable data is compared against desired benchmark levels. Qualitative data is analyzed to assess any patterns or trends that may lead to improvement opportunities. No minimum 'benchmark" standards are set for the qualitative data, but that data is filtered closely to minimize bias. After data are collected and analyzed, necessary changes in, or changes required to meet, the overall mission, educational objectives, and educational outcomes can be determined. This iterative and continuous process provides the feedback opportunity to implement program changes when or if needed. The Department Head and core MET Faculty are the implementation arm for review and change. Faculty meet regularly during the academic year (usually weekly) to consider ongoing issues, ongoing data collection, and items requiring immediate attention. The analysis, feedback, and any subsequent changes will be summarized in the MET yearly Assessment Report."

Improvement Step 2 - Evaluation of the Current-State of the MET Assessment Process

According to ABET [2], multiple methods, including both direct and indirect measures of student learning should be used to measure outcomes, and "The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program." MET Program assessment is focused on two integrated components of the MET program. These components are:

- Continuous Improvement of the MET program as a whole – to support program constituents, as well as support general ABET Accreditation requirements (criterion 1, 2, 4, 5, 6, 7 and 8).
- Ensuring our students meet MET Program Outcomes – in support of ABET Accreditation criterion 3.

Rogers [8] states that effective assessment processes:

- are "On-going and systematic at the program level"
- "Use multiple methods to measure each outcome"
- Use "Both direct and indirect measures of student learning to measure outcomes"

While our processes use multiple methods, and are systematic at the program level, changes to outcomes used by other programs within our department provide impetus for review of the use of direct and indirect measures for each outcome. The Criteria for Accrediting Engineering Programs [3] effective for reviews during the 2018-2019 accreditation cycle includes significant changes to student outcomes. Earlier criteria included 11 outcomes (listed as a through k). The new criteria now include 7 outcomes (listed as 1 through 7). While this would not normally be an issue with an engineering technology program, in our case they are a significant concern. Because we have a Mechanical Engineering Technology (MET) program housed in the same academic department as a Mechanical Engineering (ME) program, we share many resources and procedures. Our MET and ME programs share several required courses, as well as allow students to select professional elective courses from either program. In addition, our program assessment plans are closely aligned and integrated. In many cases, each program relies on the same assessment data to support evaluation of program success. To continue the ability to maximize resources, we needed to review and revise our outcomes and assessment activities.

Changes to MET Program Student Outcomes

According to ETAC of ABET [2], "Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students attain as they progress through the program." In addition, "The program must have documented student outcomes that prepare graduates to attain the program educational objectives. There must be a documented and effective process for the periodic review and revision of these student outcomes." As mentioned previously in this paper, due to lessons learned from the most recent ABET accreditation visit, and changes to EAC Criteria 3, the Outcomes of the MET program at MSU have been reviewed and revised to the following:

1. **Fundamentals / Applications**: *Demonstrate* an ability to select and apply a knowledge of mathematics, science, engineering, and technological principles, applied procedures, or methodologies, to produce practical, effective and innovative solutions to problems. (a, b, c, f)
2. **Design**: *Demonstrate* 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, b, d, e, f, k)
3. **Communication**: *Demonstrate* appropriate written, oral, computer, and technical skills to effectively communicate with individuals having a broad range of backgrounds and experience. (g)
4. **Professional and Ethical Responsibilities**: *Demonstrate* 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. (h, i, j, k)
5. **Teamwork**: *Demonstrate* 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. (e)
6. **Experimentation**: *Demonstrate* an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. (c)
7. **Professional Preparation**: *Understand and demonstrate* an ability to engage in self-directed continuing professional development, acquire and apply new knowledge as well as demonstrate a commitment to quality, timeliness, and continuous improvement. (h)

These map to the ABET a through k outcomes and the EAC ABET outcomes as shown in table 2.

Table 2 – Mapping MET Outcomes to TAC of ABET a-k Outcomes

		ABET (a-k) Outcomes										
MET Outcome	**EAC Outcome**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1. Fundamentals / Applications	1	√	√	√			√					
2. Design	2	√	√		√		√	√				√
3. Communication	3							√				
4. Professional / Ethical responsibility	4									√	√	√
5. Teamwork	5					√						
6. Experimentation	6			√								
7. Professional Preparation	7								√			

Evaluation Questionnaire

While evaluating the effectiveness of the current state, special emphasis will be placed on elimination of wasted activity. Santos, Wysk, and Torres [9] states "Shigeo Shingo identified seven main wastes common to factories:

- *Overproduction*. Producing unnecessary products when they are not needed and in greater quantities than required.
- *Inventory*. Material stored as raw material, work-in-process, and final products.
- *Transportation*. Material handling between internal sections.
- *Defects*. Irregular products that interfere with productivity, stopping the flow of high-quality products.
- *Processes*. Tasks accepted as necessary.
- *Operations*. Not all operations add value to the product.
- *Inactivities*. Machines with idle time or operators with idle time."

Identification of waste formed the framework for evaluation of the current state activity. In addition, evaluation of each current process associated with each assessment tool focused on the new program outcomes (1 through 7). A question-based approach, using the tried-and-true 5-W's (what, why, when, where, who) and 1-H (how) technique was used to guide the review. As the questions were asked, perceived impact on overall program quality, as well as effectiveness of educational outcomes assessment was determined. The questionnaire (partial) developed is shown in Figure 2.

MSU MET Program Assessment **December 2017**
Current-State "What? / Why? / When? / Where? / Who? / How?" Questionnaire

Assessment Process being Evaluated:

What? What are we doing? What data is being collected? What are we doing with the data? What should we be doing? What are the problems? What part of this is waste? What are customers getting from this?	
Why? Why are we doing this? Why is this data being collected? Why is this data valuable? Why are we collecting data here? Why are we collecting data this way? What do the customers want?	
When? When is this happening?	

Figure 2. Current-State Evaluation Questionnaire (Partial)

Each of the eight assessment tools were evaluated individually, with results used to:

- Determine the impact each had on overall program quality (scale 1 to 5, 5 high)
- Determine the impact each had on evaluation of educational outcomes (scale 1 to 5, 5 high)
- Identify the type of data collected (direct / quantitative vs. indirect / qualitative)
- Identify wasted activity associated with the tool
- Quantify the ease of use of each tool - scale 1 (easy) to 5 (difficult)
- Develop a plan for future use of the tool (keep as is / keep but revise / eliminate)
- Provide input to revision of the overall assessment activity that will be completed in the future (schedule, responsibilities, expectations, etc.).

Current State Questionnaire Summary

Student Surveys

Data collected from this tool has resulted in positive change in the past. It is easy to administer, and the time required by faculty is not excessive. Currently, data is collected twice per year. We will continue to use as is, but only for indirect evaluation of overall program quality and how well our students meet program educational outcomes. The current questionnaire will need a revision to match revised outcomes, and data collection will be changed to once per year – at the end of spring semester.

Table 3. Impact of Assessment Tool – Student Survey

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	5 (high)	1
Program Outcomes	Indirect	2 (low)	1

Department Industrial Advisory Board (IAB)

This activity supports a very important part of our program quality plan. Data collected has resulted in positive change in the past. It is easy to administer, and the time required by faculty is not excessive. Currently, data is collected once per year, in the form of suggestions and recommendations from the IAB, which does not provide direct data related to program outcomes assessment. We will continue to use as is, but only for indirect evaluation of overall program quality and how well our students meet program educational outcomes.

Table 4. Impact of Assessment Tool – IAB

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	3 (med)	1
Program Outcomes	Indirect	1 (low)	1

Employer / Alumni Surveys

Data collection is extremely difficult, as we use an on-line survey, and it is difficult to secure an appropriate level of participation. It is very time consuming and difficult to administer and a significant amount of faculty and support staff time is required. It is an important component of our assessment plan, as it provides the most direct data related to how well student meet program outcomes. Currently, data is collected once every three years.

Table 5. Impact of Assessment Tool – Employer / Alumni Surveys

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	3 (med)	5
Program Outcomes	Direct	3 (med)	5

The combination of medium impact, with a high ease of use index, lead us to the decision of revising this tool significantly and possibly eliminating it completely, and replacing the data collection activity with a new assessment tool called “Course Reviews”

Faculty Discussions

Evaluation of this tool verified that it is not a data collection tool, rather is the evaluation arm of the process. This activity will not be included as an assessment tool moving forward.

Capstone Reviews

Data collection for this tool is completed by the department Industrial Advisory Board. Department responsibility is limited to summarizing the data collected and assessing that data. It is a highly impactful tool for the assessment of ABET outcomes c, e, g, j, h, and k.

Table 6. Impact of Assessment Tool – Capstone Reviews

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	3 (med)	3
Program Outcomes	Direct	5 (high)	3

Use has resulted in positive change in the past, so we will continue to use in the future. We will revise the data collection questions to match our revised outcomes, as well as review how the data is collected and shared between programs.

FE Exam

Although this exam has been developed for engineering verses engineering technology students, all MET students are required to take this exam prior to graduating. It has been difficult in the past to get reliable data regarding the MSU MET students pass/fail rates, but the data is valuable, and easy to obtain.

Table 7. Impact of Assessment Tool – FE Exam

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	1 (low)	1
Program Outcomes	Direct	1 (low)	1

We will continue to use in the future, as well as review how the data is assessed and shared between programs.

Placement

Collection of reliable data is very difficult to complete, as students must self-report. However, the tool will continue to be utilized as is, but only for indirect evaluation of overall program quality.

Table 8. Impact of Assessment Tool – Placement

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	3 (med)	1
Program Outcomes	Indirect	N/A	1

Student Internships

Data collection for this tool is completed by the direct supervisor of students performing internships. Department responsibility is limited to summarizing the data collected and assessing that data. It is useful for direct assessment of ABET outcomes a through k.

Table 9. Impact of Assessment Tool – Student Internships

Assessment of	***Data Type***	***Impact***	***Ease of Use Index***
Program Quality	Indirect	1 (low)	1
Program Outcomes	Direct	3 (med)	1

Use has resulted in positive change in the past, so we will continue to use in the future. We will revise the data collection questions to match our revised outcomes, as well as review how the data is collected and shared between programs.

Summary of Current State Evaluation

All current assessment tools provide indirect assessment data that contributes to evaluation of program quality. Table 10 provides a matrix relating a-k outcomes to assessment tools that provide direct assessment data.

Table 10: Assessment Tools Linked to Measured Outcome

MET Assessment Tool	Impact	Direct ABET (a-k) Outcomes Measured										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Student Surveys												
Departmental Industrial Advisory Board (IAB)												
Employer Surveys and Alumni Surveys	low	√	√	√	√	√	√	√	√	√	√	√
Faculty Discussions												
Capstone Reviews	high			√	√	√	√		√		√	√
FE Exam	med	√	√	√			√			√		
Student Internship Survey Reviews	med	√	√	√	√	√	√	√	√	√	√	√
		3	3	4	3	3	4	2	3	3	3	3

As shown by the tally at the bottom of the table, each outcome is measured by at least two tools, and in some cases, by four of the assessment tools. The program feels that, to provide adequate data, a baseline of **one** high impact assessment tool must be utilized, and each outcome must be measured at least **three** times. As noted in the table above, only outcomes c, d, e, f, h, j, and k currently meet the minimum criteria for effective measurement of the outcome. A plan to address this deficiency is addressed in the future-state process development.

Improvement Step 3 – Develop the Future-State of the MET Assessment Process

Typical processes begin with specific inputs, followed by specific activities, resulting in specific outputs. The output of the quality improvement process must result in action plans resulting in activities designed to improve the quality of the process being measured – thus "closing-the-loop". The future state of our assessment process will provide the data required to effectively assess our program quality, as well as how well our students meet program educational outcomes. Figure 3 shows a flowchart of the general assessment and evaluation process that will be utilized by the MET faculty.

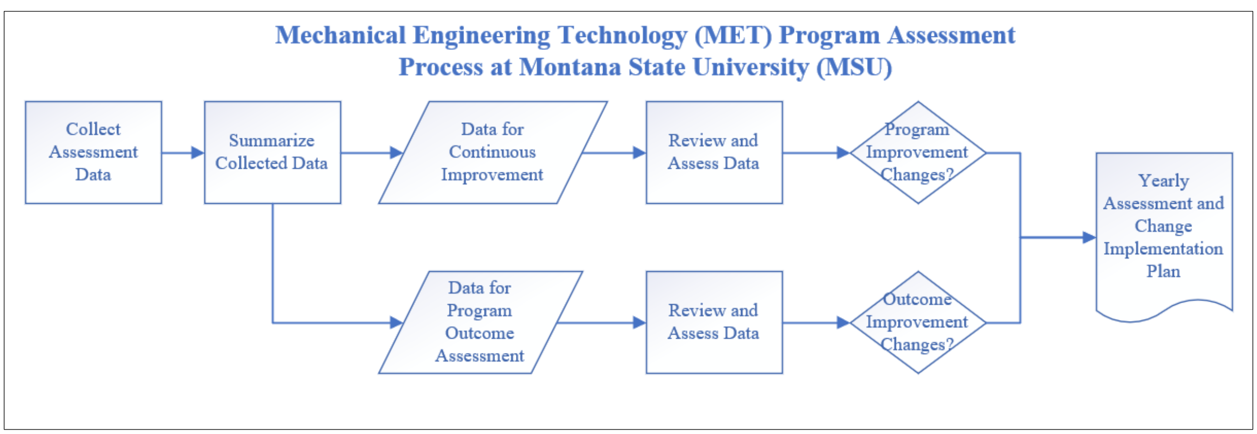

Figure 3: MET Program Assessment, Evaluation, and Documentation Flow – Future State

The tools currently utilized will provide adequate indirect assessment data, but, as noted in table 10 previously, only outcomes c, d, e, f, h, j, and k met the minimum criteria for effective measurement of the educational outcomes. To resolve this issue, an assessment tool - **Course Reviews -** will be developed and added to provide the additional assessment activity required to address this deficiency. Additionally, Employer and Alumni Surveys, as well as Faculty Discussions will be removed as assessment tools. Table 11 outlines the assessment tools that will be utilized to collect data for evaluation, as well as responsibilities and frequency of collection and evaluation.

Table 11. Assessment Responsibility Matrix for MET Educational Objectives and Outcomes

Assessment Tool	Review of Objectives	Assessment of Outcomes	Data Obtained & Compiled By	Frequency of Collection	Results Reviewed By	Mechanism & Frequency For Review
Student Interviews		Indirectly	MET Program Coordinator MET Faculty Members Department Head	Spring Semester	Faculty and Applicable Constituents	Faculty Assessment Meetings (as needed)
Dept. IAB	Direct Discussion	Indirectly	MET Program Coordinator Department Head	Fall Semester	Faculty and Applicable Constituents	IAB Annual Mtg. (October)
Capstone Reviews		Directly (c, d, e, f, h, j, k)	Capstone Course Instructor Department Head	Fall and Spring Semester	Faculty and Applicable Constituents	Faculty Assessment Meetings (as needed) IAB Annual Mtg. (October)
FE Exam		Directly (a, b, c, f, i)	Department Head MET Program Coordinator	Fall and Spring Semesters	Faculty and Applicable Constituents	Faculty Assessment Meetings IAB Annual Mtg. (October)
Placement		Indirectly	Department Head MET Program Coordinator	Summers	Faculty and Applicable Constituents	Faculty Assessment Meetings (as needed) IAB Annual Mtg. (October)
Student Internship Survey Reviews		Directly (a, b, c, d, e, f, g, h, i, j, k)	MET Internship Coordinator	Summer Semester	Faculty and Applicable Constituents	Faculty Assessment Meetings (as needed) IAB Annual Mtg. (October)
Course Reviews		Directly (a, b, c, d, e, f, g, h, i, j, k)	Assigned Professors	Throughout Academic Year per Schedule	Faculty and Applicable Constituents	Faculty Assessment Meetings (as needed)

Table 12 provides an updated matrix relating a-k outcomes to assessment tools. As specified above, to provide adequate data, a baseline of **one** high impact assessment tool must be utilized, and each outcome must be measured at least **three** times for each of the a-k outcomes. The additions (shown as x's) provide the additional assessment coverage.

Table 12: Assessment Tools Linked to Measured Outcome – Future State

		Direct ABET (a-k) Outcomes Measured										
MET Assessment Tool	**Impact**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Student Surveys												
Departmental Industrial Advisory Board (IAB)												
Capstone Reviews	high			√	√	√	√	**x**	√		√	√
FE Exam	med	√	√	√			√			√		
Student Internship Survey Reviews	med	√	√	√	√	√	√	√	√	√	√	√
Course Reviews	**high**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
		3	3	4	3	3	4	3	3	3	3	3

The new tool "Course Reviews" will be developed using the following approach:

1. Map revised outcomes to courses in the curriculum
2. Identify key courses – from which to evaluate / collect data and assessment material
3. Identify student product to evaluate
4. Develop rubrics for product evaluation

The rubrics will be designed to provide indirect assessment data for all outcomes.

Improvement Step 4 – Achieve / Implement the Future State

To complete this improvement process, the following activities must be completed:

1. Newly revised outcomes must be approved by the Industrial Advisory Board, and other program constituents.
2. The Future State Data Collection Tools must be revised to eliminate the identified wasteful activity, as well as to match the revised program educational outcomes.
3. The newly identified assessment tool – Course Review – must be developed and implemented. Data collection rubrics must be developed, assigned, and managed.
4. The process for documenting the assessment activity needs to be reviewed and revised to support assessment changes.

Conclusion

Continuously improving quality would be expected to be a process of diminishing returns as non-value-added elements are eliminated and low-quality elements are improved. After decades of improvement, one would expect that a truly optimized system might have been honed-in on. In reality, the quality targets are continuously moving and evolving, thus the quality improvement activity will never come to a conclusion. Incorporation of "Lean" principles can effectively manage and move the processes currently in use to a higher level of quality. The changes identified as part of this activity have ultimately lead to a more effective management plan that will guide our program quality and outcomes assessment into the future.

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