Mechanical Engineering Assessment Plan

NOTE: The assessment plan and results are depicted in the Criterion 3 and Criterion 4 sections of this program's self-study for accreditation under ABET, Inc. These sections are on the following pages.

CRITERION 3. STUDENT OUTCOMES

A. Student Outcomes

The ME Student Outcomes (and the associated Program Educational Objectives) are listed below as published on the centralized campus public posting at:

http://www.sdsmt.edu/Academics/Office-of-the-Provost/Assessment/ABET-accredited-Programs/ and on the ME web page at:

http://www.sdsmt.edu/Academics/Departments/Mechanical-Engineering/Accreditation---Assessment/.

The Student Outcomes and the associated PEOs are listed below again for convenience.
ABET Program Objectives and Student Outcomes

Objective 1:

Lead and/or manage effective engineering design analyses
Student Outcomes

1. Apply skills in engineering, science, and mathematics
2. Practice effective analysis
3. Conduct data analyses and analyses verification

Objective 2:

Lead, and/or manage effective engineering design teams
Student Outcomes

4. Apply effective engineering design skills
5. Demonstrate teaming proficiency
6. Participate in research and professional development

The Relationship between Program Education Objectives, Student Outcomes and ABET Criterion 3 Student Outcomes (a-k) is presented in Table 3-1.

The relationship of the ME Student Outcomes to the ABET Criterion 3 Student Outcomes (a-k) are discussed further below:

- To ***apply skills in engineering, science, and mathematics*** requires:
    - an ability to apply knowledge of mathematics, science, and engineering (a of ABET Criterion 3 a-k), which can be assessed using course exams and project work, and

- an ability to identify, formulate, and solve engineering problems (e of a-k), which can be assessed using project work.

- To ***practice effective analysis*** requires:

  - an ability to communicate your analysis results effectively (g of a-k) through organization of materials (oral or written) and using correct grammar and formatting, which can be assessed using project work, and
  - an ability to apply techniques, skills, and modern engineering tools (k of a-k) such as appropriate application of commercial software, which can be assessed using course exams and/or project work.

Table 3-1 Relationship of ME Program Educational Objectives to Student Outcomes to ABET Criterion 3 Student Outcomes (a-k)

Objectives	Outcome	ABET Criterion 3
(1) Lead/manage engineering design analyses	(1) Apply skills in engineering, science, and mathematics	a, e
	(2) Practice effective analysis	g, k
	(3) Conduct data analysis and verification	b, f
(2) Lead/manage engineering design teams	(4) Apply effective engineering design skills	c, h
	(5) Demonstrate teaming proficiency	d, j
	(6) Participate in research and professional development	f, i

Table 3-1 Relationship of ME Program Educational Objectives to Student Outcomes to ABET Criterion 3 Student Outcomes (a-k)

- To ***conduct data analyses and analyses verification*** requires:
  - an ability to design and conduct experiments both laboratory and numerical (b of a-k), which can be assessed using classroom projects, laboratory reports, and/or project work, and
  - an understanding of professional and ethical responsibility (f of a-k) by meeting project schedules and citing literature appropriately, which can be assessed using project work.

- To ***apply effective engineering design skills*** requires:
    - an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, which necessitates developing an appropriate problem specification including functional design requirements and the submission of a safe, cost-effective design that can be manufactured "first-time right", and
    - an ability to recognize the economic/environmental/global/societal impact of the design (h of a-k), all of which can be assessed using project work.

- To ***demonstrate teaming proficiency*** requires:
    - an ability to function on multi-disciplinary teams (d of a-k) as evidenced by team members contributing to the project, having a knowledge of the issues, respecting the diverse perspective of others, and practicing the core values of the department, and
    - a knowledge of contemporary issues (j of a-k) as evidenced by the team reporting an alignment of the project and the issues involved to issues of current debate. Outcome (h) adds economic and environmental to global and social content. (c of a-k),

- To ***participate in research and professional development*** requires:
    - an understanding of professional and ethical responsibility (f of a-k) and
    - a recognition of the need for, and ability to engage in life-long learning (i of a-k) as evidenced by joining a professional society (e.g., ASME), and/or engaging in undergraduate research, and/or by submitting a clearly written memo on how to remain engaged in the profession after graduation.

To summarize, Table 3-2 below maps ME Student Outcomes to ABET Criterion 3 Student Outcomes (a-k).

Table 3-2 Mapping of ME Student Outcomes to ABET Criterion 3 Student Outcomes (a-k)

	ME Student Outcome	1	2	3	4	5	6
ABET Outcome							
a		X					
b				X			
c					X		
d						X	
e		X					
f				X			X
g			X				
h					X		

	ME Student Outcome	1	2	3	4	5	6
ABET Outcome							
i							X
j						X	
k			X				

Table 3-2 Mapping of ME Student Outcomes to ABET Criterion 3 Student Outcomes (a-k)

B. Relationship of ME Student Outcomes to ME Program Educational Objectives

The ME Student Outcomes lead to achieving the ME Program Educational Objectives as discussed briefly below:

- To ***lead and/or manage effective engineering design analysis*** requires:
    - an ability to apply correct skills in engineering, science, and mathematics (elements of engineering design) with few conceptual or procedural errors; and an ability to identify a problem through a clear formulation of the solution with minimal errors and a solid understanding of the fundamental theories and principles (**ME Outcome 1**),
    - an ability to couple problem solving methodology to the engineering design methodology in a continuous well-organized manner; to perform in a professional manner by meeting schedules, submitting clearly written and formatted documents or presentations, and citing all appropriate literature; and to apply appropriate analytical, computational, and/or experimental analysis tools with an understanding of the fundamental theories, software principles, and/or measurement principles involved (**ME Outcome 2**),
    - an ability to design and conduct experiments (either numerical or experimental) and clearly state givens and assumptions and have a knowledge of data acquisition systems, including software and sensors and an understanding of the need to verify data and provide a clear verification of analyses results via an appropriate independent method (**ME Outcome 3**).

- To ***lead and/or manage effective engineering design teams*** requires:
    - an ability perform as a group with individual and collective assignments to clearly define the problem, including the need (with given specifications and constraints understood and focused into functional requirements), and an understanding of the global and societal impacts of the product to be designed (**ME Outcome 4**),
    - an ability to perform as a team, with each team member contributing to the project, having knowledge of the issues, respecting the perspectives of others, and attending project meetings; and the team investigating and reporting how the project aligns with any contemporary issues of local, regional, national, or international interest or under current debate (**ME Outcome 5**),

- an ability to recognize the importance of life-long learning by interacting with team members having diverse opinions and/or by participation in professional societies and/or by participating in undergraduate research (**ME Outcome 6**).

CRITERION 4. CONTINUOUS IMPROVEMENT

Assessment is defined as one or more processes that identify, collect, and prepare the data necessary for evaluation. Evaluation is defined as one or more processes for interpreting the data acquired though the assessment processes in order to determine how well the ME Student Outcomes are being attained.

A. ME Student Outcomes

A.1 Process Documentation

This section contains a step-by-step explanation of how the assessment for ME Student Outcomes is performed. Example data tables, charts, worksheets, rubrics, etc. are shown to illustrate the process for Student Outcome 1.
Please note that Appendix E contains a similar step-by-step explanation for ME Student Outcomes 2-6.

Table A.1 of Appendix E presents a discussion of the coherence of ME curriculum to ME Student Outcomes and the coherence of ME Student Outcomes to ME Program Educational Objectives. For purposes of discussion, one section of this table is presented below in Figure 4-1 addressing ME Student Outcome 1.

Included in Figure 4-1 below are the strategies and actions (column 1) in place to meet Student Outcome 1, the metric used to measure achievement of Student Outcome 1 (column 2), the mapping of the outcome to ABET Criterion 3 (column 3), some of the courses used to perform the assessment (column 4), the assessment instrument or method (column 5), the proposed review cycle (column 6), and the actions taken in response to the assessment (column 7).

Finally, the shaded cells in the table include assessment strategies that involve supplementary instruments (see Section A.3 below) and a description of those instruments (in this case results from the FE exams). All six ME Student Outcomes have an associated outcome rubric that sets the criteria being measured and the metric (Proficient, Apprentice, or Novice). These rubrics are presented in Appendix E and an example is discussed below for Student Outcome 1.

Figure 4-2 shows the instruments used in the assessment process. Included in Figure 4-2 is the mapping of the individual ME Student Outcomes to ABET Criterion 3 Student Outcomes (a-k). For convenient reference, information contained in the table includes the ME Program Educational Objectives and ME Student Outcomes along with the a-k list of ABET Criterion 3. The assessment instruments include Primary and Supplementary instruments. The primary instruments include classroom exams and projects, classroom design activities, lab reports, and senior capstone design. The first three instruments are used to individually assess specific ME Student Outcomes (shaded table cells) and together are inclusive of all of ABET Criterion 3 Student Outcomes a-k (last column). Capstone design is used to assess all six ME Student Outcomes and is, therefore, inclusive of all of ABET Criterion 3. By covering ABET Criterion 3

Student Outcomes in this manner, we ensure assessment ABET Criterion 3 Student Outcomes (a-k) in detail every semester and assessment across the curriculum from the freshman year to the senior year.

ME Student Outcomes Assessment Strategy[5]

ME Program OBJECTIVE 1: **Lead and/or manage effective engineering design analysis**

OUTCOME 1: **Apply skills in engineering, science, and mathematics**

Strategies and Actions	Target Performance Measure or Metric for This outcome	Outcome mapped to ABET 2000 Criterion 3. (a-k)	Courses in which outcome addressed	Assessment Method, or instrument used	Review cycle[6]	Actions taken or proposed in response to assessment
Required subjects in mathematics are applied in the ME curriculum to understand the governing laws and concepts in mechanics, thermal science, and controls	80% of students in ME core sequence score as apprentice or proficient.	a, e	ME 110, ME core ME electives, ME 477,479	Class exams, Capstone Design Projects, Outcome 1 Rubric/Capstone Design Rubric	Reviewed semiannually by ME faculty	Subject deficiencies identified relative to courses and corrective actions taken
Faculty evaluate the technical content of the capstone design projects including PDR's and CDR's	80% of students in capstone design score as apprentice or proficient.	a, e	ME 477/479 ME core	Class exams, Capstone Design Projects, Outcome 1 Rubric/Capstone Design Rubric	Reviewed semiannually by ME faculty	Subject deficiencies identified relative to projects and corrective actions relayed to faculty coordinator and faculty advisors.
The ME program highly recommends students sit for the Fundamentals of Engineering (FE) exam	85% pass rate on FE exam	a	NA	Pass rate	Reviewed annually	Subject deficiencies (discipline exam) identified relative to courses and corrective actions taken

Figure 4-1 Assessment Strategy (from Table 2 of Appendix E)

[5] Table 2 from Appendix E

[6] The review cycle frequency shown was proposed 9 years ago when we began a restructuring of our ABET process. We have found over the years that less frequent reviews are sufficient for student outcome assessments and help to ensure sustainability.

Primary

Instruments	ME Objective #1 Out. 1	Out. 2	Out. 3	ME Objective #2 Out. 4	Out. 5	Out. 6	ABET Criteria 3 (a-k)
Classrooms Exams, Projects	a, e						} a-k
Classroom Design Activities		g, k		c, h	d, j	i	
Lab Reports			b, f				
Capstone Design	a, e	g, k	b, f	c, h	d, j	i	a-k
Supplementary							
FE Exam/OOE	a					f	a, f
Prof. Soc.				h	j	f, i	f, h, i, j
Undergrad Research						f, i	f, i

OBJECTIVE 1:
Lead and/or manage effective engineering design analyses

Outcomes

1 Apply skills in engineering, science, and mathematics (a,e)
2 Practice effective analysis (g, k)
3 Conduct data analyses and analyses verification (b, f)

OBJECTIVE 2:
Lead and/or manage effective engineering design teams

Outcomes

4 Apply effective engineering design skills (c, h)
5 Demonstrate teaming proficiency (d, j)
6 Participate in research and professional development (f, i)

ABET a-k

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern eng tools necessary for eng practice

Figure 4-2 Assessment Matrix[7]

[7] This graphic was drafted in 2006 before the change in wording for ABET outcome (c) and (h) and is presented here for process explanation only. Outcome (c) states: an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. Outcome (h) adds economic and environmental to global and social content.

The supplementary instruments include the Fundamentals of Engineering Exam, professional society membership, and participation in undergraduate research (discussed later).

Again, please note that an example of an assessment of ME Student Outcomes 2-6 is presented in Appendix E. All assessments will be available at the time of the visit.

When we began our current ABET assessment process back in 2006, we assessed all ME Student Outcomes every semester and all faculty members contributed – but not necessarily every semester. Since our last successful visit in 2010, we began to reduce the frequency of assessing each outcome, depending upon results from our latest evaluation. Nevertheless, most of the ME Student Outcomes are assessed annually by multiple methods and by multiple faculty members. For example, Table 4-1 gives an example of faculty assessment assignments for the Fall 2014. These assignments are made by the department head, Dr. Langerman, and are provided to faculty at the beginning of each semester along with an individual assignment sheet (an example is given in Figures 4-3a,b for ME Student Outcome 1). The individual rubrics for assessing each outcome assigned are also provided. For example, Figure 4-4 presents the rubric for assessing ME Student Outcome 1–Apply skills in engineering, science, and mathematics.

The materials on display for the evaluators will include, in part, course notebooks collated over the last academic year (2015-2016). These notebooks will be labeled as to the course and the relative ME Student Outcomes being assessed. The notebooks will contain the following:

1. Table of Contents,
2. ABET Syllabus,
3. Fall 2015/Spring 2016 Assignment Matrix (e.g., Table 4-1),
4. Individual Faculty Assessment Assignment (e.g., Figure 4-3a,b),
5. ME Student Outcome(s) assessed and applicable rubrics (e.g., Figure 4-4) including:
    a. Description of the instrument used for the assessment (e.g., Classroom Project description),
    b. Assessment results,
    c. Examples of the student work,
6. Examples of student exams,
7. Examples of student homework,
8. Detailed descriptions of Projects/Design Activities/Lab Reports if applicable.

Also on display will be assessment results from capstone design projects (see Appendix E for Capstone Design Assessment Rubrics) including photographs of past design fair activities. Additionally, assessment data from the Supplementary instruments including:

1. FE exam results,
2. Professional society activities,
3. Undergraduate research assessment results (see Figure 4-2 for ME Student Outcomes assessed using this instrument).

The display will have materials readily available for convenient cross reference including:

1. Mission and vision statements with a list of ME Program Educational Objectives and ME Student Outcomes,
2. Assessment rubrics and metrics, assessment history,
3. Textbooks,
4. Support courses for the ME program (materials available at a separate station)

Table 4-1 Faculty ABET Assessment Assignments Fall 2014

Fall 2014 assignments														
	ME Objective #1						ME Objective #2						ME Outcomes	ABET outcomes
ME outcomes	Out. 1		Out. 2		Out. 3		Out. 4		Out. 5		Out. 6		1-6	a-k
Instrument	exams	cap des	clsrm des act	cap des	Lab repts	cap des	clsrm des act	cap des	clsrm des act	cap des	clsrm des act	cap des		
ABET outcomes	a,e	a,e	g,k	g, k	b,f	b, f	c,h	c,h	d, j	d,j	i	i		
abata														
ash	110	477		477		477		477		477		477	1-6	a-k
bedillion	110												1	a,e
bestgen							125L						4	c,h
degen														
dolan							264/269		264/269				4,5	c,h,d,j
ellingsen														
heydari			352		351				351				2, 3,5	g,k,b,f,d,j
huang	110												1	a,e
kalanovic														
kjerengtroen	110												1	a,e
korde							264/269		264/269				4,5	c,h,d,j
lalley							125L						4	c,h
langerman	313												1	a,e
lessani					331								3	b,f
muci			216										2	g,k
romkes														
shahbazi														
widener			322								UR		2,6	g,k,f,i

MISSION STATEMENT

"The mission of the Mechanical Engineering program is to prepare our graduates for leadership roles in the mechanical engineering profession by:

- *offering a quality education fostering a distinctive curriculum ccentuating design and project-based learning,*
- *committing to individual development while emphasizing the values of teamwork in a culturally diverse, multidisciplinary environment,*
- *encouraging undergraduate and graduate research nurturing creative solutions to complex engineering problems."*

OBJECTIVE 1:

Lead and/or manage effective engineering design analyses

Outcomes

1 Apply skills in engineering, science, and mathematics (a,e)

2 Practice effective analysis (g, k)

3 Conduct data analyses and analyses verification (b, f)

ABET a-k

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of eng solutions in a global economic, environmental and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Table 4-1 Faculty ABET Assessment Assignments Fall 2014

Dr. Michael Langerman –ABET Fall 2014 Assignments (9/10/14)

PRIMARY FACULTY ASSESSMENT ASSIGNMENTS [1]

Table 1. From ABET assessment plan-Table 4

	ME Objective #1			ME Objective #2		
ME Outcomes	Out. 1	Out. 2	Out. 3	Out. 4	Out. 5	Out. 6
Instrument	exams	clsrm des act	lab reports	clsrm des act	clsrm des act	clsrm des act
ME 313	a,e					

[1] Assignments highlighted

1. Consider outcomes assessment when preparing exams, design activities, and lab reports.
2. Modify evaluation rubrics as you see fit for your particular course, but document for later discussion.
3. Assess student performance with evaluation rubrics and base on the following grade range:
   Proficient: 85-100% Apprentice: 70-85% Novice: Below 70%
   Note: A minimum of C is required in core courses, so this enforces that novice students should not be able to graduate and is consistent with our 2004 ABET self-study.
4. Retain copies of proficient, apprentice, and novice work (i.e., the good, the bad, and the ugly) along with evaluation rubric.

SUPPLEMENTARY FACULTY ASSESSMENT ASSIGNMENTS [1]

Table 2. From ABET assessment plan-Table 1

	ME Objective #1			ME Objective #2		
ME Outcomes	Out. 1	Out. 2	Out. 3	Out. 4	Out. 5	Out. 6
Undergrad Res.						f,i

[1] Assignments highlighted

1. FE Exam/Order of the Engineer
   - # of graduating ME students, # of students taking FE exam, and # of students passing (raw data)
   - # of graduating ME students, # of students joining the Order of the Engineer
2. Professional societies
   -Document professional society activities related to outcome assessment items in Table 2 (f,h,i, and j of ABET a-k).
   -Mainly for student section advisors, but may overlap with faculty/student involvement with professional societies (i.e., paper/presentation to professional society for undergrad research, etc.).
3. Undergrad research including REU
   -If you have undergraduate students involved in research, document items specifically related to outcome assessment items in Table 2 (f and i of ABET a-k).
4. Additional student activities/employer feedback has relevancy to ABET accreditation and we can separate as follows:
   Testimonials – unsolicited email feedback from employers
   Anecdotal – student activities that address a-k (for example the Chile trip by Yasmin), to showcase what our students are involved with and to show the opportunity exists
   Alumni news – articles on achievements of our alumni

(Submission instructions on reverse side)

Figure 4-3a Faculty Assessment Assignment (page 1)

Forward supplementary items to Jason who will collect those in a general ABET notebook. These will not be the primary instruments for assessment/evaluation but more the icing on the cake. The general notebook may be referenced in our next ABET self-study.

OBJECTIVES/OUTCOMES

OBJECTIVE 1: Lead and/or manage effective engineering design analyses
Outcomes:
1. Apply skills in engineering, science, and mathematics (a, e)
2. Practice effective analysis (g, k)
3. Conduct data analyses and analyses verification (b, f)

OBJECTIVE 2: Lead and/or manage effective engineering design teams
Outcomes:
4. Apply effective engineering design skills (c, h)
5. Demonstrate teaming proficiency (d, j)
6. Participate in research and professional development (f, i)

ABET a-k

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Figure 4-3b Faculty Assessment Assignment (page 2)

Outcome 1 Rubric – Apply skills in engineering, science, and mathematics (a, e)

ABET Criterion 3 Outcome a – An ability to apply knowledge of mathematics, science, and engineering						
Criteria	**3 Proficient**	**2 Apprentice**	**1 Novice**	**3's**	**2's**	**1's**
Applies Knowledge of Mathematics, Science, and Engineering	Applies correct science and mathematical principles; no conceptual or procedural errors	Applies correct science and mathematical concepts; contains minor errors	Applies incorrect science and mathematical concepts and procedures	___	___	___
ABET Criterion 3 Outcome e – An ability to identify, formulate, and solve engineering problems						
Engineering Skills	Identifies the problem through a clear formulation of the solution with minimal errors and a solid understanding of the fundamental theories and principles.	Identifies the problem through a clear formulation of the solution with some errors and some misunderstanding of the fundamental theories and principles.	Problem is incorrect with several errors and a misunderstanding of the fundamental theories and principles.	___	___	___
			Total			

Figure 4-4 Assessment Rubric for ME Student Outcome 1

A.2 Achievement of ME Student Outcomes

As mentioned at the beginning of Section A.1 above, each ME Student Outcome has an associated outcome rubric and each rubric has three metric measures including: 1) Proficient, 2) Apprentice, and 3) Novice (e.g., Figure 4-4 above). The associated percentage measure is, respectively, ≥ 85%, 70%-84%, and ≤ 69%.

For example in Figure 4-4, which presents the rubric for ME Student Outcome 1, the basis for the assigned percentage is the degree to which the criterion (column 1 of the rubric) is achieved. If exams are used as the assessment instrument, then students scoring greater than or equal to 85% would fall into the Proficient category. The metric for achieving the outcome is that 80% of the students or teams score as Proficient or Apprentice (i.e., the target performance listed in Figure 4-1, column 2).

The semester-by-semester process used by the ME program to document and demonstrate the degree to which the ME Student Outcomes are attained is presented graphically in Figure 4-5 below as a 5-step process.

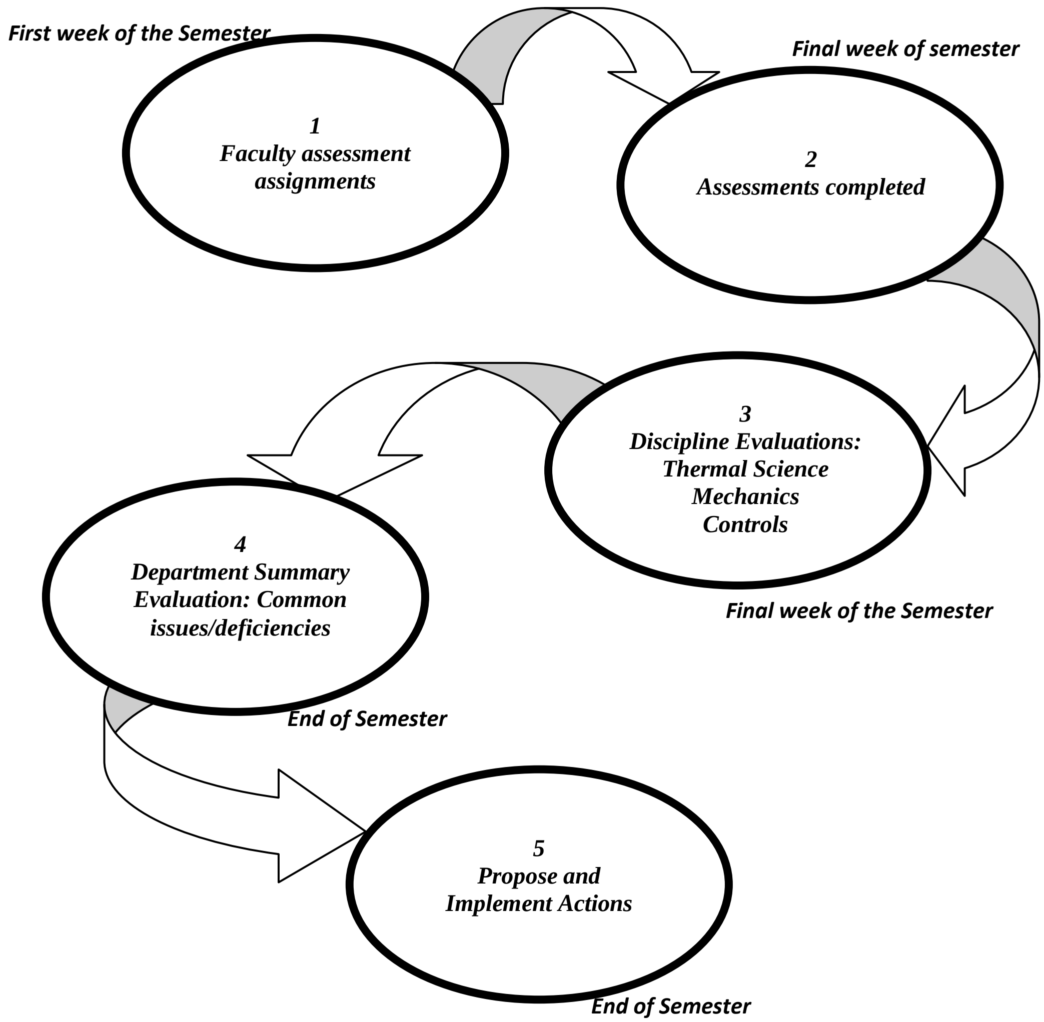


Figure 4-5 ME Student Outcomes 5-Step Assessment Process

The 5-step ME Student Outcomes assessment process begins with faculty assignments (Step 1) at the beginning of each semester (e.g., Table 4-1 and Figure 4-3a,b). Upon receiving their assignments, the individual faculty member conducts their assessments over the span of the semester (Step 2). By the final week of the semester, the assessment results are complete and the three ME sub-disciplines (thermal science, mechanics, and controls and robotics) meet individually (Step 3) to review the results and to strategize, if necessary, on how to overcome any deficiencies within the sub-discipline. In addition, the ME program design coordinator calls

together faculty to review issues that arise in design-specific classes such as senior capstone design and together identify strategies to address the issues or deficiencies[8].
Following these group meetings, a meeting of the overall department faculty and needed staff (usually an end-of-the-semester retreat) is called (Step 4) to identify common assessment deficiencies and attendant strategies and to document the results in a Summary Evaluation table as discussed later and to recommend proposed actions, if necessary (Step 5). For clarity, the steps are repeated below. A brief example of the process is also given.

Step 1 –Faculty members are given assignments at the beginning of the semester.

Step 2 – Faculty complete their assessments by the end of the semester.

Step 3 – Faculty meet within their sub-disciplines to address any deficiencies.

Step 4 – The department faculty and staff meet at the end of the semester to address common deficiencies.

Step 5 – Document a strategy to address identified deficiencies.

Figure 4-6 below shows the number of assessments conducted of each of the six ME Student Outcomes over the last 13 semesters (does not include the supplementary assessments to be discussed later). For example, ME Student Outcomes 1 and 2 were assessed over 50 and 51 times, respectively, from F10 to Sp16. ME Student Outcomes 3-6 were assessed between 36 and 49 times over the same period.

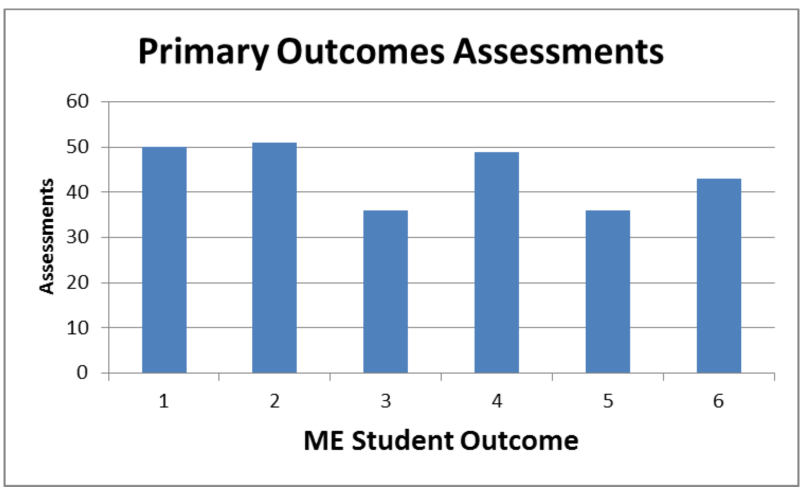


Figure 4-6 The number of ME Student Outcomes assessments conducted over the last thirteen semesters (F10-S16).

As mentioned, a brief example of the assessment process is presented here for Student Outcome 1. Figure 4-7a,b shows the Outcome Assessment for Outcome 1 for ME 313 (Heat

[8] During academic years 2013-2014 through 2014-2015 the department met at the end of the spring semester only to review and evaluate results from both the fall and spring semesters.

Transfer) for the Fall of 2014. As discussed earlier, achieving the outcome occurs when 80% of the students or teams score as Proficient or Apprentice with no more than 20% of the students or teams scoring in the Novice category (Figure 4-1). The assessment instrument used for this case was the three exams given during the semester. As indicated in Figure 4-7a,b, only 69% of the students scored as Proficient/Apprentice and, consequently, the 80% metric was not met and the ME Student Outcome 1 for ME 313 F14 was not achieved. As noted in Figure 4-7b, the students had trouble with finite-difference techniques in the second exam and temperatures to use in determining average emissivity and absorptivity from spectral values in the third exam. When all ME Student Outcomes assessments assigned have been completed, the sub-disciplines (thermal science, mechanics, and controls and robotics) meet to review the results and propose actions, if necessary. Continuing with the example above, the thermal science faculty members met to address results from thermal science courses assessed in the Fall/Spring of 2014/2015, which included Introduction to Thermodynamics, Thermodynamics II, Thermal-Fluids, and HVAC, in addition to Heat Transfer. Figure 4-8 presents the documentation of that meeting (Step 3) and a summary discussion of the meeting is given briefly below.

Figure 4-8 shows that the thermal science discipline faculty members assessed ME Student Outcomes 1-3 during AY 2015. The ME Student Outcomes were met in three courses, but were not met in ME 313 (ME Student Outcome 1) or ME 331 (ME Student Outcome 3). In ME 313 (Heat Transfer), only 69% of the students reached the Proficient/Apprentice rank. For ME Student Outcome 1 the typical problem with those reaching only the rank of Novice was trouble with finite-difference techniques in the second exam and reference temperatures to use in determining average emissivity and absorptivity from spectral values in the third exam.

Proposed actions include considering the use of MatLab in numerical problems rather than our current use of Excel. MatLab is used in their numerical math class, which is a prerequisite to ME 313. For the second exam, students had trouble with what temperature to use in determining absorptivity. This seems to be a recurring problem that may be overcome by working more in-class example problems. For ME Student Outcome 3, the instructor (newly hired faculty member) acknowledges that the problem given was probably too advanced for the students in ME 331. A notebook with the results from all assessments conducted from AYs 2011-2016 will be available to the ABET evaluator during the visit.

Outcome 1 – Apply skills in engineering, science, and mathematics

Assessment Instrument(s):	**Exams, projects, labs**
ABET criteria 3:	**a, e**
Course:	**Heat Transfer, ME 313, F2014**
Instructor:	**Dr. Mike Langerman**
Metric:	**(P/A>80%)**

I. Assignment:

Test 1, problem 1:

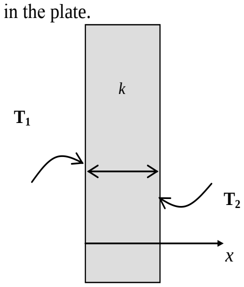
A large plane wall has a constant temperature on the left side, T_1, and a constant temperature on the right side of T_2. As in your homework, show "mathematical formulation" and then solve for the variation of temperature in the plate.

Assumptions

1 Heat conduction is steady and one-dimensional

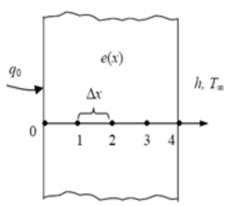
2 Thermal conductivity is constant.

3 There is no heat generation in the wall.



Test 2, problem 1:

Steady heat conduction in a 1D medium with conductivity k and internal generation e (W/m3). Using the energy balance method derive the finite difference equations for the left and right boundaries. Show your work!



Test 3, problem 3:

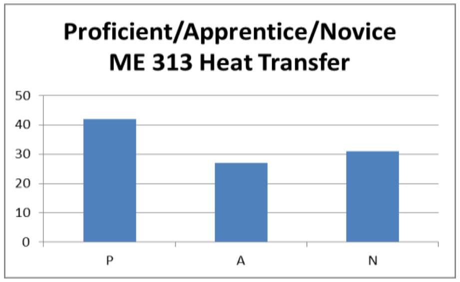
Two very large parallel plates are maintained at uniform temperatures of T_1 =800 K and T_2 = 350K. Surface 2 is a black body. The emissivity surface 1 is 0.6. Determine the net rate of radiation heat flux between the plates.

Figure 4-7a Assessment Results for Outcome 1 (F14 Heat Transfer-problem statement)

Outcome 1 Rubric – Apply skills in engineering, science, and mathematics (a,e)

Criteria	3 **Proficient** (85-100%)	2 **Apprentice** (70-84%)	1 **Novice** (<70%)	3's	2's	1's
ABET Criteria Outcome a – An ability to apply knowledge of mathematics, science, and engineering						
Applies Knowledge of Mathematics, Science, and Engineering	Applies correct science and mathematical principles; no conceptual or procedural errors	Applies correct science and mathematical concepts; contains minor errors	Applies incorrect science and mathematical concepts and procedures	**23 15 4 42**	**5 7 15 27**	**7 11 13 31**
ABET Criteria Outcome e – An ability to identify, formulate, and solve engineering problems						
Engineering Skills	Identifies the problem through a clear formulation of the solution with minimal errors and a solid understanding of the fundamental theories and principles.	Identifies the problem through a clear formulation of the solution with minor errors and some misunderstanding of the fundamental theories and principles.	Problem is incorrect with several errors and a misunderstanding of the fundamental theories and principles.	—	—	—
			Total	**42 %**	**27 %**	**31 %**

III. Assessment Results:



Assessment result: (69 % P/A, metric not met)

The students had trouble with finite-difference techniques in the second exam and temperatures to use in determining average emissivity and absorptivity from spectral values in the third exam.

Figure 4-7b Assessment Results (graphic) for Outcome 1 (F14 Heat Transfer)

E ABET Assessment Summary Evaluation
Thermal Science Core and Electives
Fall 2014/Spring 2015

Core Courses Assessed

Course #	ME 211	ME 312	ME 313	ME 331	ME 402
Title	Thermodynamics I	Thermodynamic II	Heat Transfer	Thermo-Fluid Dynamics	Gas Dynamics
Instructor	Shahbazi	Abata	Langerman	Lessani	Shahbazi
ME Outcome	2	1	1	3	3
Metric	P/A[1]>80%	P/A[1]>80%	P/A[1]>80%	P/A[1]>80%	P/A[1]>80%
a-k	g,k	a,e	a,e	b,f	b,f

1-P-proficient, A-apprentice

Assessment Results

ME 211; Outcome 2: Practice effective analysis (g, k)

Issues/Deficiencies	Outcome 2 – P/A~ 93; Metric met Group project – Radon pollution of a mine using conservation mass.
Proposed Actions	Outcome 2 – NA

ME 312; Outcome 1: Apply skills in engineering, science, and mathematics (a, e)

Issues/Deficiencies	Outcome 1- P/A~ 92%; Metric met Exam on Exergy and cycle analysis.
Proposed Actions	Outcome 3- NA

ME 313; Outcome 1: Conduct data analysis and analyses verification (b, f)

Issues/Deficiencies	Outcome 1- P/A~69%; Metric not met The students had trouble with finite-difference techniques in the second exam and temperatures to use in determining average emissivity and absorptivity from spectral values in the third exam.
Proposed Actions	Outcome 1 Excel was used to solve the numerical problems. We may consider using MathLab in the future. Matlab is used in their numerical math class, which is a prerequisite to ME 313. Student historically have had trouble with which temperature to use in determining absorptivity. More in-class example problems may help resolve this confusion.

ME 331; Outcome 3: Apply skills in engineering, science, and mathematics (a, e)

Issues/Deficiencies	Outcome 3- P/A~ 45; Metric not met The project was a Fluent application that was likely too advanced for a junior-level class. They lacked the background.
Proposed Actions	Outcome 3- Provide more introductory material over more classroom sessions.

ME 402; Outcome 3: Conduct Analysis and Analysis Verification (b,f)

Issues/Deficiencies	Outcome 3- P/A~80; Metric met Shock tube design using computational model
Proposed Actions	Outcome 3-NA

Figure 4-8 Discipline (Thermal Science) Summary Evaluation of ME Student Outcomes, F14

Table 4-2 below documents results obtained from all sub-disciplines during the AY15. The cell letter abbreviations are M=Met (80% metric), NM=Not Met. In 35 of the 42 ME Student Outcomes assessments conducted in AY15, the outcome was achieved (83%).

In 7 of the 42 (17%), the outcome was not achieved. On an outcome-by-outcome basis, the achievement percentages are, for AY15: ME Student Outcome 1 (50%), ME Student Outcome

2 (78%), ME Student Outcome 3 (86%), ME Student Outcome 4 (100%), ME Student Outcome 5 (100%), and ME Student Outcome 6 (75%).

These percentages for AY 15 are typical for other AYs. In fact, the 80% metric for ME Student Outcome 1 over the entire assessment cycle was met 56% of the time. Likewise, for ME Student Outcomes 2-6, the percentages were 84%, 90%, 98%, 95%, and 99%, respectively over the same period. Results from all AYs will be available at the time of the visit.

Table 4-2 Thermal science/mechanics/controls/design assessments for AY15

	ME Student Outcome					
Therm Sci-AY2015	1	2	3	4	5	6
ME 211-Intro Thermodyn		M				
ME 312-Thermo II	M					
ME 313-Heat Transf	NM					
ME 331-Thermo Fluids			NM			
ME 402-Gas Dyn			M			
Mechanics –AY2015						
ME 216-Intro Solid Mech		NM				
ME 322-Mach Design I		M				
ME 422 Machine Des II				M		
Undergrad Resrch						M
Controls - AY2015						
ME 221-Dyn of Mechanisms	NM					
ME 351-Mechatroncis		M		M		
ME 351-Mechatroncis Lab			M		M	
ME 352-Intr Dyn Syst (F/S)		M/M		M/M		
ME 352-Intr Dyn Sys (F)		NM				
ME 426-Mech Sys Analy L			M			
ME 453-Controls Lab			M			
Design Specific - AY2015						
ME 110-Intro to Mech Eng	NM			M	M	M
ME 125-Des Manufact L				M		
ME 264-Elec/Mec Prod Dev				M	M	
ME 269-Energ Prod Dev				M	M	
ME 427-CAD/CAM				M		
ME 477-Capstone Design	M	M	M	M	M	M
ME 479-Capstone Design	M	M	M	M	M	NM

Table 4-2 Thermal science/mechanics/controls/design assessments for AY15

M=Meets 80% metric, NM=does Not Meet 80% metric

A.3 Supplementary Student Outcome Assessments

As indicated in back in Figure 4-2, three Supplementary instruments are used to assess ME Student Outcomes 1, 4, 5, and 6 (ABET Criterion 3- a, f, h, i, and j). The Fundamentals of Engineering (FE) exam is used as a supplementary assessment instrument for ME Student Outcomes 1 and 6 (ABET Criterion 3- a and f). Professional society membership is used as a supplementary assessment instrument for ME Student Outcomes 4, 5, and 6 (ABET Criterion 3- f, h, i, and j) and undergraduate research is used as a supplementary assessment instrument for Student Outcome 6 (ABET Criterion 3- f, and i). Finally, a brief description of an institutional assessment of students is given. Results from this assessment will be available at the time of the visit.

Fundamentals of Engineering (FE) Exam

Supplementary assessments of Student Outcomes 1 and 6 were conducted using FE exam results. For Student Outcome 1 – Apply skills in engineering, science, and mathematics (ABET Criterion 3 a – an ability to apply knowledge of mathematics, science, and engineering) the metric for achieving the outcome is, of the students taking the exam, 85% pass (see Figure 4-1). Figure 4-9, indicates that this metric has been met two out of the last five academic years[9]. Our students scored at or above the national average in three of the last five academic years and , in fact, the SDSM&T mechanical engineering students scored above the national average in the last two academic years. It should be noted that the mechanical engineering program does not require that students sit for the exam.

For ME Student Outcome 6 – Participate in research and professional development (ABET Criterion 3 f – an understanding of professional and ethical responsibility) the metric for achieving the outcome is that at least 50% of the graduating seniors value professional registration by sitting for the FE exam. The ME program graduates about 65 seniors every academic year. From AY2011 to AY2015, 169 ME seniors sat for the FE exam or about 52% of our graduating seniors, thereby slightly exceeding the 50% metric.

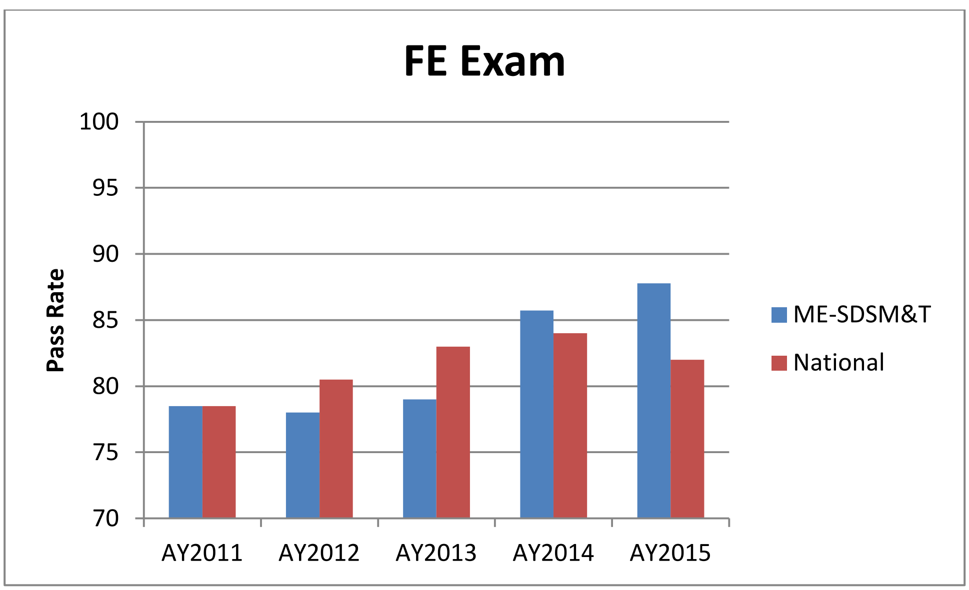


Figure 4-9 Fundamentals of Engineering (FE) Exam: ME student pass rate (AY 2012-2015)

[9] It should be noted at the printing of this document AY 2016 results were not yet available.

Professional Society Membership

Supplementary assessments of Student Outcomes 4, 5, and 6 were conducted using Professional Society membership. The metric for achieving each outcome is that 50% of the ME students are members of professional societies where the impact of engineering solutions on society are discussed, contemporary issues in engineering and science are debated, an understanding of professional and ethical responsibility is emphasized, and a recognition of the need to engage in life-long learning is present.

With the mechanical engineering program's emphasis on design, students are made aware of professional societies and their role in developing design codes and standards along with maintaining ethical integrity within the engineering profession. Additionally, active membership in student chapters is strongly encouraged and monitored within the professional development portion of grading in both ME 110: Introduction to Mechanical Engineering and ME 477: Mechanical Engineering Design I.

There are five predominant student chapters that attract ME students. These include the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) advised by Dr. Lessani; the American Society of Mechanical Engineers (ASME) advised by Dr. Ash; the Society of Automotive Engineers (SAE) advised by Dr. Dolan, the Students for the Exploration and Development of Space (SEDS) advised by Dr. Ash; and the Society of Women Engineers (SWE) advised by Dr. Degen who also advises the Tau Beta Pi engineering honor society chapter at the South Dakota Mines.

All of these organizations focus on professional development (e.g., design competitions, plant tours, conference participation, and industry presentations), service (e.g., K-12 outreach and campus participation), and social activities (e.g., networking with industry members, annual hog roasts, ice cream socials, etc.) that help develop the social network and camaraderie amongst students, faculty, and alumni.

ASHRAE is a specialized student organization that has an emphasis in the HVAC area. There is a very active Black Hills professional chapter, which has always drawn student members into the ASHRAE organization. Additionally, the Black Hills ASHRAE chapter often contributes to the ME 404: HVAC course by donating ASHRAE textbooks containing psychometric tables to students taking the course. In 2012-2013, a group of students formally revitalized the ASHRAE student chapter and was advised by Dr. Simmons the first two years before transitioning to Dr. Lessani as the advisor. With the formation of the student chapter, more collaborative events were held with the Black Hills chapter that often included tours of local construction projects incorporating LEED certification.

The ASME student chapter at the SDSM&T is recognized as one of the most active ASME student chapters within the midwest region. A core team of first-year students through seniors work together to maintain continuity of the officer team in sharing past traditions while developing new activities in the three focus areas of professional development, service, and social activities. There are numerous highlights since the last ABET accreditation visit in September 2010. Shortly after that visit, the ASME Student Design Competition team that developed an autonomous material sorter placed 2nd in the world finals held at the November 2010 ASME International Mechanical Engineering Congress and Exposition (IMECE) in Vancouver, BC.

Carlos Beatty Jr. (IENG ’13) and Colin McGowan (ME ’14) were elected by peer university sections to serve as the Student Regional Chair in consecutive years (2011 & 2012) on the ASME Student Sections Committee (SSC) thereby contributing to service at the international level. At the same time, Dr. Ash was selected by the district leader to serve as the Student Regional Advisor on the SSC (2011-2014). This committee transitioned to the ASME Student Section Enterprise Team (SSET) where Dr. Ash was elected as the chair (2014-2017). In this role, he serves as the North America Student Regional Advisor and oversees 4 other faculty (South America, Europe, Middle East, and Asia), and 10 Student Regional Chairs from around the world. Christian Jones (2013), Michael Kelly (2014), and Michael Mansfield (2015) have received competitive funding to participate in the ASME Student Leaders Training Conference the past three respective years, which typically fund only 50-100 participants each year.

Students have continued to maintain active participation at the ASME Student Professional Development Conference each spring. In 2014, students/teams placed 1st in the ASME Old Guard Poster Competition, 2nd in the ASME Old Guard Oral Competition, and 5th in the ASME Student Design Competition. In 2015, a student placed 4th in the ASME Old Guard Oral Competition. Additionally, the ASME student section was recognized in 2011 by the South Dakota Board of Regents with the Award for Organizational Leadership. In 2015, ASME International recognized the section with the ASME Outstanding Student Section Award. Andy Koosman (2012), Carlos Beatty Jr. (2013), and Megan Frager (2014) have all received regional nominations for the ASME Charles T. Main Award, which placed them amongst 10 students worldwide for consideration of this prestigious award.

The SAE student chapter is equally active. Professional development, service, and social activities are coordinated through the SAE Chapter and CAMP, but are directed more to individual teams. Many of the teams associated with the Center of Excellence for Advanced Manufacturing and Production (CAMP) are sponsored through SAE (e.g., Formula SAE, SAE Mini-Baja, SAE Aero Design, SAE Zero-Emissions Snowmobile and SAE Supermileage).

Here teams are large enough to coordinate outreach activities that relate directly to their project in order to create an interest in an engineering and science education with K-12 students. With CAMP, these vehicle competitions provide the mechanism for experiential (project-based) learning while developing teaming proficiency. CAMP teams often return from national competitions with high placement in design, communications, and overall system performance.

Tables 5-5 and 5-6 in Criterion 5 list competition results for two major CAMP vehicle teams comprised of SAE student members. While the Collegiate Design Series activities are the main focus of student activities in SAE, the chapter has become very active in itself. The officers hold regular weekly meetings and actively contribute many outreach activities. They held several all-chapter meetings including hosting Rob Mudge of RPM and Associates to speak on the business and human resource side of engineering. They held a Lego Car Design competition at one meeting. They took part in a Myth Busters program for grade school students during Engineer's week. They did outreach events at the Corral Drive Middle School Science Day and at Hill City Schools. SDSM&T is one of very few schools in the country to take part in all 5 of the major SAE design competitions. By leveraging resources through the CAMP program and the Departments, especially the Mechanical Engineering Department, all can be successful.

During the 2010-2012 timeframe, there was a substantial amount of student interest toward careers in the aerospace field. We have a very active NASA South Dakota Space Grant Consortium (SDSGC) and students receive education, research, and internship stipends for areas of interest to NASA. With the wide interest, a SDSGC Project Innovation Grant was proposed by and awarded to Dr. Ash (ME), Dr. Tolle (ECE), and Dr. McGough (MCS) to reform the Students for the Exploration and Development of Space (SEDS) so students with this career interest would have a nationally recognized student organization to be a part of.

Four active ASME members who rose to the challenge of reforming the SEDS student organization in the Fall 2011 semester. Since then, the SEDS section has grown to the multidisciplinary student organization envisioned that encompasses all realms of students interested in space exploration and the aerospace field. The SEDS chapter participates in the SEDS SpaceVision conference each year to learn of cutting edge areas within the aerospace fields. Participating in SEDS and aerospace projects (NASA Robotic Mining, Mines Association of Rocketeers) have all assisted students with obtaining full-time positions within the aerospace community with companies such as NASA, SpaceX, Blue Origin, Lockheed Martin Space Systems, XCOR Aerospace, etc. The SEDS chapter was recognized by the South Dakota Board of Regents in 2014 with the Award for Organizational Leadership.

Additionally, ME students also participate in the campus student chapter of Tau Beta Pi, the engineering honor society representing the entire engineering profession. To be eligible for membership in Tau Beta Pi, students must 1) be pursuing an engineering or computer science degree, 2) have a GPA in the top 1/8th of their junior class or top 1/5th of their senior class, and 3) display exceptional character through an essay, letter of recommendation, or volunteering with the chapter members.

The engineering honor society at SDSM&T was Sigma Tau from 1923 until Sigma Tau merged with Tau Beta Pi in 1974 with the societies' belief that a single, strong honor society would better serve the engineering profession. On April 22, 1974 the South Dakota Alpha Chapter of Tau Beta Pi was established at SDSM&T. The total initiated membership affiliated with the South Dakota Alpha Chapter exceeds 1,800. The Shawn R. Schwaller Memorial Endowment for the South Dakota Alpha Chapter at the SDSM&T was established in 2014 through the generosity of Dr. Larry Simonson, SD A '69.

The South Dakota Alpha Chapter has been very active in recent years. The 2015 national convention was held in Providence, RI, on October 29-21, 2015. 5 students (1 ME) and 1 faculty (Dr. Cassandra Degen, Mechanical Engineering) attended this convention. The 2016 national convention will be held in San Diego, CA, on October 6-8, 2016. Our chapter hosted the national convention in Rapid City in 1996. Each spring, district conferences are held for chapters in their region. Tau Beta Pi divides the United States into 16 districts. District 12 includes SDSM&T, 2 chapters in MT, 5 chapters in CO, 3 chapters in UT, 2 chapters in ID, and 1 chapter in WY. The 2016 district conference was held in Laramie, WY, and 6 SDSM&T students attended (2 ME). There is no cost to individuals from our chapter who wish to attend the district conference.

Tau Beta Pi members planning to attend graduate school are eligible to apply for a $10,000 Tau Beta Pi Fellowship. Students from SDSM&T have been very successful in the past several years. Approximately 35 Fellowships are awarded nationally each year.

Tau Beta Pi undergraduate student members are eligible to apply for a $2,000 Tau Beta Pi Scholarship. Students from SDSM&T have been very successful in the past several years. The Scholarship Program was started in 1999 and of the 2,039 Tau Beta Pi Scholars selected since then, 94 are members of the South Dakota Alpha Chapter. In the past 5 years, 35 SDSM&T students have been awarded scholarships (9 ME). There will be approximately 250 Tau Beta Pi Scholarship awarded for the 2016-17 school year.

Tau Beta Pi members at SDSM&T are involved in several projects throughout the year. Recent and current projects include assisting with sponsorship for Career Fairs, tutoring at elementary/middle schools, guiding tours for engineers' week, etc. Members are encouraged to get involved with university, professional, or community events associated with Tau Beta Pi.

Although the primary emphasis regarding professional society membership in ASME, SAE, etc., is on active membership, supplementary assessments of Student Outcomes 4, 5, and 6 were conducted using professional society membership alone. As discussed at the outset, the metric for achieving each outcome is that 50% of the ME students are members of professional societies where the impact of engineering solutions on society are discussed, contemporary issues in engineering and science are debated, an understanding of professional and ethical responsibility is emphasized, and a recognition of the need to engage in life-long learning is present.

Determining if this metric is met depends primarily upon membership lists provided by the societies, which have been found to be, in the past, incomplete (e.g., students get coded incorrectly and do not appear on the SDSM&T roster). Therefore, a professional development survey is administered in the senior year in ME 477 and for the 2015-2016 academic year, 54.5% of the senior students reported being active in a professional society, which places membership just above our target metric of 50%. While students earn a small portion of their grade for completing the survey, this grade is not affected by whether they are a professional society member or not. These results by survey are consistent with previous results found by summing membership numbers and removing duplicates where students are members of multiple professional societies. Overall, there are many opportunities for students to engage in and develop professionally from the student organizations available on-campus and more than half of the ME students partake in that opportunity.

Undergraduate Research

Additional supplementary assessments of ME Student Outcome 6 were conducted during AY 2011-2016 based upon undergraduate participation in research. For ME Student Outcome 6 – Participate in research and professional development (ABET Criterion 3- f [an understanding of professional and ethical responsibility] and i [a recognition of the need for, and an ability to engage in life-long learning]) the metric for achieving the outcome is that 80% of the students involved with undergraduate research will score as apprentice or proficient using the rubric given in Figure 4-10.

Results from this assessment show that 87% of the ME students (41 students) engaged in research and who were assessed from fall 2010 to fall 2015 scored as proficient or apprentice, therefore, meeting the metric of 80%. Results will be available at the time of the visit.

Undergraduate Research Rubric: Outcome 6

Student name: ____________________________________ **# of months participating in UG research:** ___________

Project Advisor: ____________________________________ **Evaluator name:** ____________________________________

Scoring
Please circle the appropriate score based on the performance of the student or indicate if the item does not apply (N/A) for the type of work that the student is doing.

	Criteria	3 Proficient	2 Apprentice	1 Novice	Circle Score			
1	**Active participation in project meetings (6, f)**	Prepares and gives comprehensive progress presentations on a regular basis. Consistently provides input that contributes to the success of the project.	Prepares and gives progress presentations and provides project input on a regular basis.	Seldom prepares and gives progress presentations. Sporadically provides project input.	**3**	**2**	**1**	**N/A**
2	**Meeting project deadlines (6, f)**	Meets project deadlines more than 90% of the time.	Meets project deadlines between 80% and 90% of the time.	Meets project deadlines less than 80% of the time.	**3**	**2**	**1**	**N/A**
3	**Citing information sources (6, f)**	Always cites information sources. Uses an appropriate format for citing references.	Cites most of the information sources. Uses and appropriate format for citing references.	Cites only some of the information sources. Typically doesn't use an appropriate format for citing references.	**3**	**2**	**1**	**N/A**
4	**Verifying data and results (6, f)**	Always tries to verify the data and results obtained.	Most of the time tries to verify the data and results obtained.	Seldom tries to verify data and results obtained.	**3**	**2**	**1**	**N/A**
5	**Preparing technical reports (6, f)**	Needs minimum advice, help and feedback to prepare a short technical report.	Needs some advice, help and feedback to prepare a short technical report.	Needs a considerable amount of advice, help and feedback to prepare a short technical report.	**3**	**2**	**1**	**N/A**
6	**Identifying safety concerns in the context of the project (6, f)**	Always pays close attention to safety and tries to identify possible safety concerns. Always follows the safety procedures that are in place.	From time to time tries to identify possible safety concerns. Always follows the safety procedures that are in place.	Does not participate in an active fashion in the identification of possible safety concerns. Typically follows the safety procedures that are in place.	**3**	**2**	**1**	**N/A**
7	**Making good use of available equipment and resources (6, f)**	Helps maintain the equipment in excellent condition and always tries to optimize the use of available sources.	Always makes good use of available equipment and resources.	Most of the time makes good use of available equipment and resources.	**3**	**2**	**1**	**N/A**
8	**Learning new material independently (6, i)**	Every week spends some time learning new material independently.	Every month spends some time learning new material independently.	Occasionally spends some time learning new material independently.	**3**	**2**	**1**	**N/A**
9	**Synthesizing information obtained in a literature search (6, i)**	Needs minimum advice, help and feedback to prepare the literature review for a given topic.	Needs some advice, help and feedback to prepare the literature review for a given topic.	Needs a considerable amount of advice, help and feedback to prepare the literature review for a given topic.	**3**	**2**	**1**	**N/A**
10	**Participating in technical conferences (6, i)**	Attends all the sessions relevant to his/her interest areas.	Attends most of the sessions relevant to his/her interest areas.	Only attends some of the sessions relevant to his/her interest areas.	**3**	**2**	**1**	**N/A**
				Average Score (Sum of the scores for each applicable item divided by the number of applicable items)	**/ =**			

Comments:

Figure 4-10 Undergraduate research rubric

Institutional Assessment

Learning outcomes in the General Education program can be aligned with the ABET a-k outcomes since the majority of students take a small number of courses to meet their general education requirements. The following tables are based on an analysis of all students between 2012 to the present. The General Education courses listed in the tables below account for the courses that 70% to 90% of all students take to meet a given core outcome. The blue shading indicates which ABET (a) through (k) Student Outcomes these courses address to a high degree.

GEP Objective #1: *Students will write effectively and responsibly and understand and interpret the written expression of others.*

ABET Outcomes → / **High-Enrollment GenEd courses that meet Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
ENGL 101 - Composition I							■				
ENGL 201 - Composition II							■				
ENGL 279 - Technical Communications I				■		■	■				■
ENGL 289/289L - Technical Communications II				■		■	■				■

GEP Objective #2: *Students will communicate effectively and responsibly through speaking and listening.*

ABET Outcomes → / **High-Enrollment GEP courses meeting Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
SPCM 101 - Fundamentals of Speech							■				
ENGL 279 - Technical Communications I							■				
ENGL 289 - Technical Communications II							■				

GEP Objective #3: *Students will understand the organization, potential, and diversity of the human community through study of the social sciences*

ABET Outcomes → / **High-Enrollment GEP courses meeting Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
PSYC 101 - General Psychology						■		■	■	■	
SOC 100 - Introduction to Sociology						■		■	■	■	
HIST 151 - American History I						■		■	■		
GEOG 101 – Introduction to Geography								■	■	■	
POLS 100 – American Government						■	■	■	■	■	

GEP Objective #4: *Students will understand the diversity and complexity of the human experience through study of the arts and humanities*											
ABET Outcomes → **High-Enrollment GEP courses meeting Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
HIST 121 - Western Civilization I											
HIST 122 - Western Civilization II											
HUM 100 - Introduction to Humanities											
PHIL 100 - Introduction to Philosophy											
ENGL 210 – Introduction to Literature											

GEP Objective #5: *Students will understand and apply fundamental mathematical processes and reasoning.*											
ABET Outcomes → **High-Enrollment GEP courses meeting Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
MATH 102/102L - College Algebra											

GEP Objective #6: *Students will understand the fundamental principles of the natural sciences and apply scientific methods of inquiry to investigate the natural world.*											
ABET Outcomes → **High-Enrollment GEP courses meeting Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
Chemistry 112 – General Chemistry											
CHEM 114 – General Chemistry II											
GEOL 201 – Physical Geology											
Physics 213 – University Physics I											
Physics 211 – University Physics II											

Objective #7: *Students will recognize when information is needed and have the ability to locate, organize, critically evaluate, and effectively use information from a variety of sources with intellectual integrity*											
ABET Outcomes → **High-Enrollment GEP courses meeting Objective ↓**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
ENGL 101 - Composition I											
ENGL 201 - Composition II											
ENGL 279 - Technical Communications I											
ENGL 289 - Technical Communications II											

As described in Criterion 1, Section A, the assessment of the attainment of general education outcomes is the Collegiate Assessment of Academic Proficiency (CAAP) exam. Between 1995 and 2014, all students were required to take and pass the CAAP exam. Beginning in 2014, students with ACT scores of a certain level were exempt from the requirement to pass the CAAP exam. This exemption provision appears to be reducing the number of SDSM&T students taking the CAAP by approximately 90%.

Historically, SDSM&T student outperform students system wide in all four subject areas of the test. Figure 4-11 below shows the percentage of SDSM&T students passing the CAAP at the first attempt as compared to all other students attending a public university in South Dakota. SDSM&T students score the highest in Math and science reasoning, as might be expected.

	Writing		Math		Reading		Science	
Year	Mines	System	Mines	System	Mines	System	Mines	System
2014	94.9%	89.4%	100%	98.0%	96.2%	93.3%	100%	98.80%
2013	96.1%	91.7%	99.8%	98.2%	98.8%	93.7%	99.8%	99.0%
2012	93.8%	90.4%	100%	97.8%	97.8%	94.1%	100%	98.2%
2011	93.6%	91.9%	100%	97.7%	96.4%	94.6%	99.7%	98.8%
2010	96.5%	92.4%	100%	98.0%	97.2%	94.6%	100%	99.0%

Figure 4-11, Pass Rates on CAAP proficiency exam by subscores

B. Continuous Improvement

The following discussion describes the use of the ME Student Outcomes assessment results to implement improvements in the program. The discussion begins with reference to Figure 4-5 (reprinted below for convenience), and specifically Steps 3-5.

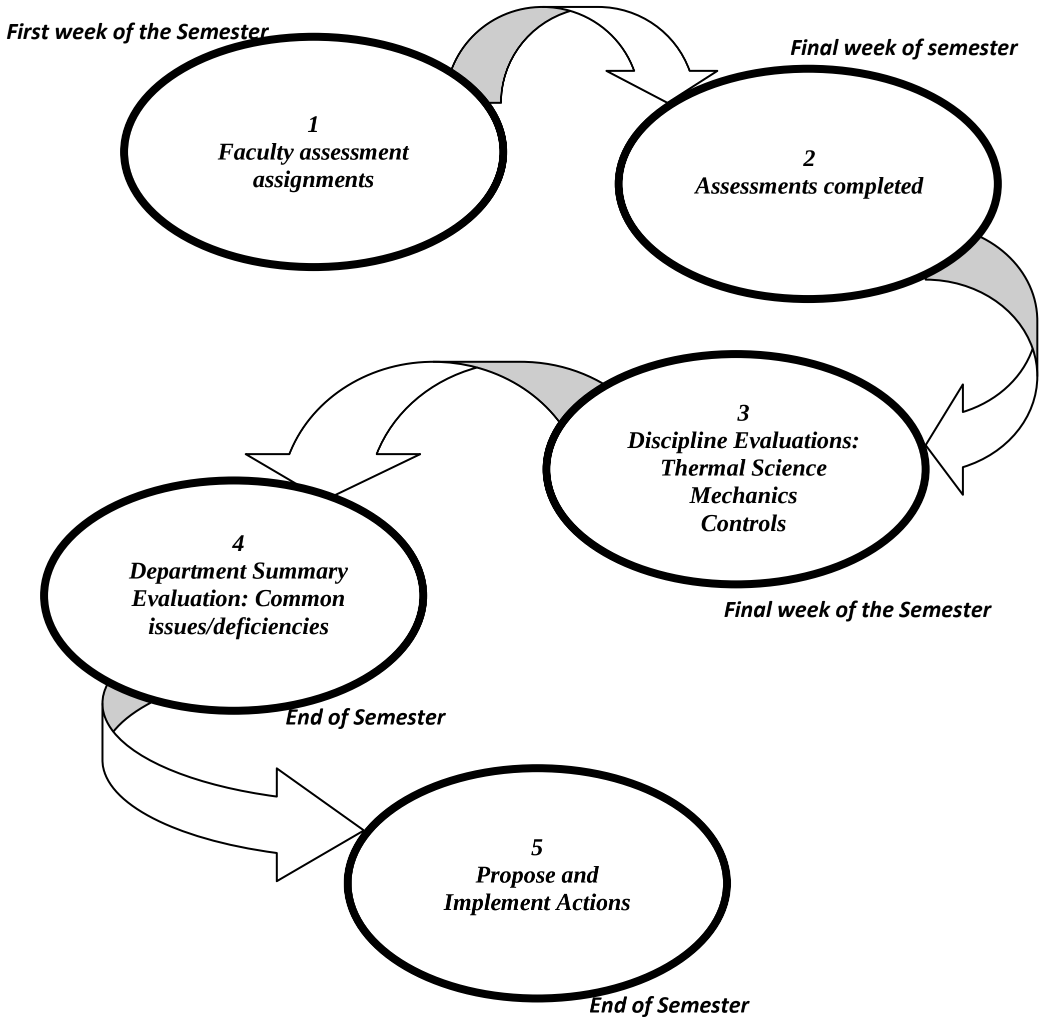


Figure 4-5 ME Student Outcomes 5-Step Assessment Process

As discussed back in Section A.2, faculty members within the three sub-disciplines and design meet to evaluate the assessments they conducted and to summarize common concerns (Step 3 above), if any, and prepare a report documenting these concerns (e.g., Figure 4-8) and present this report to all program faculty members in an end-of-semester department meeting. Similarly, during the department meeting, reports from all groups are evaluated and a department Summary Evaluation is drafted (Step 4 above). Again, using ME Student Outcome 1 for discussion purposes, an excerpt from the department Summary Evaluation for AY 2011 is presented below in Figure 4-12. The entire group of Summary Evaluations will be available for review during the general visit. Actions implemented based upon department Summary Evaluations are discussed in the next section.

B.1. Actions to Improve the Program

The department Summary Evaluations were used to enact program modifications over this assessment cycle. Table 4-3 below provides the semester-by-semester listing of common issues/deficiencies, proposed actions that were made, and the result from the action. More detail will be provided in an aggregate notebook for review at the time of the general visit. To provide more detail regarding the reasoning of assessment evaluations made since 2010, a few specific course changes/additions that occurred are discussed below[10]. Overall assessment/evaluation results are provided in Table 4-3.

> **ME 110/110L – Introduction to Mechanical Engineering**. This lecture/lab course sequence was modified to provide more of a focus on student professional development and to make students more aware of the focus areas within mechanical engineering. Additional topics were added including, units, vectors, forces, equilibrium, stress, strain, material behavior, hydrostatic pressure, and buoyancy, based on assessment of sophomore-level courses (AY11-12).
>
> **ME 125L – Design for Manufacturing**. This 1-credit hour course was added to provide an introduction to engineering design via fundamental knowledge of conventional manufacturing operations including machining and 3D printing processes. The class includes introductory lectures on marketing and graphic design. A very important topic in this class is the essential element of shop/lab safety. The importance of the "first-time-right" philosophy is stressed, which has helped to address DFM issues observed with some senior capstone design projects that required rework of designed components (AY11-12).
>
> **ME 210 – Statics of Mechanisms.** This course was added in AY15 as a result of issues/deficiencies identified in previous AYs. This change was made to better prepare students for courses in the mechanics and controls sequences. Feedback from ME faculty teaching these courses indicate an improvement if static skills when students enter the second semester sophomore year.

There were several Mechanical Engineering course additions/modifications made over this assessment cycle to provide more options and flexibility for students.

> **ME 269/269L – Energy Systems Product Development and Design/Lab**. This course was developed by the Pearson Professorship in Sustainable Energy, Dr. Umesh Korde, to focus on energy systems design for a sophomore-level course.

[10] ( ) indicate the AY in which the issue/deficiency first arose.

ME 262 – Product Development. This 2-credit hour course was eliminated based on the restructuring of ME 264/264L to provide consistency between the two product development and design courses.

ME 264/264L – Electromechanical Systems Product Development and Design/Lab. This course that had been a 1-credit hour lecture and 1-credit hour lab was adjusted to a 2-credit hour lecture and 2-credit hour lab to add more content consistent with the new ME 269/269L and reduce confusion for students when registering for courses. The focus of this course is electromechanical systems.

ME 265/265L – Product Design and Development – Introduction to Systems Engineering / Lab. A third option is being made available for the 2016-2017 academic year. The course presents useful tools and structured methodologies that support the product development practice and provides a brief introduction to selected systems engineering topics. In addition, it strives to develop in the students the necessary skills and attitudes required for successful product development in today's competitive marketplace. This course is being developed by Dr. Karim Muci in the context of Office of Naval Research STEM funding grant received by him and several ME faculty members including Drs. Bedillion, Degen, Ellingsen and Huang.

ME 430 –Wind Energy – Dr. Lidvin Kjerengtroen developed this 3-credit hour senior elective to focus on wind energy topics including the solid and fluid mechanics considerations.

ME 432/432L – Experimental Stress Analysis – Dr. Marius Ellingsen developed this 4-credit hour lecture/lab senior elective to further develop experimental mechanics expertise for those students who have an interest in this area.

ME 457– Intermediate Dynamics – Dr. Mark Bedillion developed this 3-credit hour senior elective to focus on both 2- and 3-dimensional kinetics and kinematics.

ME 499 – Mechanics: Viscoelastic Solids – Dr. Cassandra Degen developed this 3-credit hour senior elective covering polymer mechanics and viscoelasticity.

Fall 2010/Spring 2011 – Mechanical Engineering: ABET Assessment Summary of ME Student Outcomes

ME Student Outcome	Assessment Instruments Used	Courses	ABET a-k	Common Issues/Deficiencies	Proposed Actions
1. Apply skills in engineering, science, and mathematics	1. Classroom exams & projects 2. Capstone Design 3. FE exam/OOE	Fall 2010 ME 211, 216, 313, 316, 352, 455, 477 Spring 2011 ME 216, 221, 312, 322, 331, 479	a, e	Underclass students having difficulty understanding context of engineering. Upperclass students having difficulty with comprehensive problems involving multiple subject areas. Insufficient time to cover critical material. Large gap between dynamics and senior electives that need it. Issues with academic dishonesty appearing. Difficulty with teaching sophomore ME's and servicing senior CEE's at the same time. Senior design students want to work on a specific project, but do not take supporting senior electives.	Discuss more of the context of engineering to develop a conceptual understanding. (Dan) Develop tutoring program to assist students in ME programs. (Duane/Jason) Consider junior-level comprehensive mechanical design course. (Lidvin/Umesh) Need judicious use of time to meter out course material. (Umesh) Incorporate dynamics throughout mechanics sequence. (Marius) Discussions with Civil Eng. faculty. (KJ, Vois) Provide guidelines on coursework needed for specific projects. (Jason)

Figure 4-12 Excerpt from the Department Summary Evaluation for AY 2011

Table 4-3 ME Department Summary Evaluation Results

F10/S11

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
1. Apply skills in engineering, science, and mathematics	Underclass students having difficulty understanding context of engineering.	Discuss more of the context of engineering to develop a conceptual understanding. (Dan)	Subsequent semesters indicate improvement – problem not as evident – see results below
		Develop tutoring program to assist students in ME programs. (Duane/Jason)	We have hired peer mentors (mostly seniors) to assist underclassmen but find students typically do not take advantage of mentors.
	Upper-class students having difficulty with comprehensive problems involving multiple subject areas.	Consider junior-level comprehensive mechanical design course. (Lidvin/Umesh)	Still under investigation
	Insufficient time to cover critical material.	Need judicious use of time to meter out course material. (Umesh)	Subsequent semesters indicate improvement
	Large gap between dynamics and senior electives that need it.	Incorporate dynamics throughout mechanics sequence. (Marius)	Subsequent semesters indicate improvement
	Issues with academic dishonesty appearing.	Emphasize ethics	Ethics is one focus of professional soc membership. Some improvement in subsequent semesters.
	Difficulty with teaching sophomore ME's and servicing senior CEE's at the same time.	Discussions with Civil Eng. faculty. (KJ, Vois)	Civil Eng. Dept. was opposed to swapping statics; dynamics. ME dept will investigate separate sections or our own statics course (see below).
	Senior design students want to work on a specific project, but do not take supporting senior electives.	Provide guidelines on coursework needed for specific projects. (Jason)	Subsequent semesters indicate improvement

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
2. Practice effective analysis	Having difficulty with problem solving and relying on prior knowledge to attempt problems. Issue of students who do not check if answer is reasonable. Use of discipline-specific software difficult at junior-level and step-by-step instructions needed.	Teach how problem is to be solved, so they understand the process. (Vois) Discussions related to estimating reasonable solutions. (Karim) Focus on the use of discipline specific software for verification of hand calculations for junior-level courses. (Mike)	Subsequent semesters indicate improvement Subsequent semesters indicate improvement Subsequent semesters indicate improvement
3. Conduct data analyses and analyses verification	Metric was met	NA	NA
4. Apply effective engineering design skills	Only about 50% of the teams had a functional system at the time of the design fair. Some issue with professionalism who did not have large poster.	These teams should only receive a novice at best on product performance. (Jason) Provide example of what expectations are. (Jason)	Subsequent semesters indicate improvement (see F12/S13). Subsequent semesters indicate improvement
5. Demonstrate teaming proficiency	Some of the students have weak technical writing skills.	Request regular meetings between provost, heads, and English faculty. (Mike)	Problems seem ongoing. We have met with Liberal fac.
6. Participate in research and professional development	Metric was met	NA	NA

F11/S12

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
1. Apply skills in engineering, science, and mathematics	Lack of statics, math, and physics (free bodies) background; teaching to two different audiences. Students don't have good study habits Dimensions (units) Need to have more room in 352 curriculum to include control material Attendance is an issue; oral communication barrier	ME to teach our own statics and dynamics class. Talk to math and physics department about their class offerings. Meet with freshmen on early learning requirements Emphasize in ME 110 Talk with EE faculty about 352 Class discussions, homework, and tests should be consistent. Give out study guides before exams	In F14 we introduced our own statics course. Initial assessment indicates a strong improvement. Subsequent semesters indicate improvement (see F12/S13). ME fac now rotate teaching 352 and the curriculum now includes controls and other ME material. Subsequent semesters indicate improvement

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
2. Practice effective analysis	Students not retaining concepts from previous courses Students don't have basic concepts of statics	Replace one test with several smaller, closed-book quizzes Integrate some FE questions into course exams	Ongoing problem Before we began offering our own statics class (see above)
3. Conduct data analyses and analyses verification	Metrics were met	NA	NA
4. Apply effective engineering design skills	Metrics were met	NA	NA
5. Demonstrate teaming proficiency	Metrics were met	NA	NA
6. Participate in research and professional development	Metrics were met	NA	NA

F12/S13

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
1. Apply skills in engineering, science, and mathematics	Study habit issues; issues with free body diagrams, units, and statics. Students have fundamental problems setting problems up Trouble with friction forces, friction concepts, Hooke's law (have to cover basics in physics)	Spring 2014 we will be offering 2 sections of Statics Investigate an additional freshman course emphasizing units and problem solving methods Weekly emails on reading and example assignments Faculty will look into concept inventory tests	Initial assessment indicates a strong improvement in subsequent semesters. Beginning in F14 we offer an additional frshm class ME 125/125L. Subsequent semesters indicate improvement Being offered in select courses beginning in the F14. Assessments to come.
2. Practice effective analysis	Problem solving skills, handing in messy assignments Quality of reports is deteriorating	Faculty to use discretion in the fact that they refuse to grade homework that is turned in messy and to develop written communication standards Dr. Kj will circulate his homework expectations	Some improvement but problems persist.
3. Conduct data analyses and analyses verification	This Outcome was not assessed.	NA	NA
4. Apply effective engineering design skills	better use of units in ME 322 (A larger percentage of teams had their project completed at time of design fair than previous years). Metric met	NA	NA
5. Demonstrate teaming proficiency	Metric met	NA	NA

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
6. Participate in research and professional development	Low engagement in professional societies for freshmen students	Second presentation in Oct/Nov (ME 110) about professional societies	Significant improvement in subsequent semesters

F13/S14

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
1. Apply skills in engineering, science, and mathematics	Students occupied with other end-of-semester projects; not enough time to study for final Students copying solution manual; do not have appropriate physics, mathematics, and other fundamental concepts background	Discuss moving due dates a week earlier before last week of semester Choose homework from different textbooks; ME110 should be improved to better prepare for higher level classes. Dr. Korde to detail 265 process to other faculty. New STEM faculty to look into reasons why students don't retain first-year information	Ongoing problem. Some faculty have adopted this hw policy with some success.ME 110 was updated and assessments are forthcoming but this issue seems less prevalent in subsequent semesters.
2. Practice effective analysis	Although overall metric was met, problems with formatting reports. Will provide examples of appropriate formatting.	NA	NA
3. Conduct data analyses and analyses verification	Although overall metric was met, issues with ABET outcome b (ability to design and conduct experiments as well as to analyze and interpret data) so will continue to emphasize verification and convergence studies. Problems with using an array of analysis software so we will limit available software.	NA	NA
4. Apply effective engineering design skills	Outcome was met	NA	NA
5. Demonstrate teaming proficiency	Outcome was met	NA	NA
6. Participate in research and professional development	Outcome was met	NA	NA

<u>F14/S15</u>

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	<u>Result</u>
1. Apply skills in engineering, science, and mathematics	Fall ME 110 content was too complex for first-year students. Students had difficulty understanding finite-difference and using Excel to complete analysis. What temperatures to determine average emissivity and absorptivity. Students have difficulty in applying mathematics. Have difficulty analyzing engineering problems. Trouble drawing FBD and kinetic diagram.	Scale back course content to focus more on fundamentals, problem solving, units. Spend more time on these issues for these problems. Consider moving toward project-based learning and more practical applications.	Subsequent semesters indicate improvement In later semesters, fac began using MatLab in place of Excel with some improvement in student scores. Subsequent semesters indicate improvement. We have discussed issues with math faculty with some minor anecdotal student improvement. F14 was the first semester we began offering our own statics class. Subsequent semesters indicate improvement. ME 125L, project based course was introduced in F14. Assessments forthcoming.
2. Practice effective analysis	Some students were weak in statics. Some students were weak with units. Math deficiency was primary observation (chain rule, partial derivatives, function of multiple variables).	Wait until cohort comes through that took ME statics (Fall 2014 or later). Wait until cohort comes through that took transformed ME 110 course (Fall 2014 or later) Consider making Calc III a prerequisite.	F14 was the first semester we began offering our own statics class. Subsequent semesters indicate improvement. Ongoing problem. Still considering.
3. Conduct data analyses and analyses verification	Metrics were met.	NA	NA
4. Apply effective engineering design skills	Metrics were met.	NA	NA
5. Demonstrate teaming proficiency	Metrics were met.	NA	NA
6. Participate in research and professional development	ME 477- Poor reflection on learning experiences as part of their final report.	Emphasize importance of this leading up to submission of final report.	Subsequent semesters indicate improvement

F15

ME Student Outcome	Common Issues/Deficiencies	Proposed Actions	Result
1. Apply skills in engineering, science, and mathematics	Students having difficulty with trigonometry and mass/weight concepts (Final exam in ME 110 and ME 210) Difficulty with mathematics (differentiation and integration) in junior-level courses. 74% of the students were at the Proficient & Apprentice level. Some students did not hand homework in regularly.	Make Trig a co-requisite of ME 110 and assess benefit in ME 210 in Fall 2016 with concept inventory. Reconsider whether the 80% metric is realistic. Require a 60% or better average on mechanics homework to pass the class. Consider holding recitation sessions.	 TBD
2. Practice effective analysis	Metric met.	NA	NA
3. Conduct data analyses and analyses verification	Metric met.	NA	NA
4. Apply effective engineering design skills	Students have difficulty in explaining project summary, analysis, and results in ME 110 written reporting. P/A = 78.9%. Some students did poorly on safety quiz the 1st time. P/A = 67%. Metric met in ME 264, 269, 316, and 477.	Spend more time emphasizing content that needs to be contained in written report. Require a C or better on safety exam to continue on. Multiple attempts allowed.	TBD
5. Demonstrate teaming proficiency	Metric met.	NA	NA
6. Participate in research and professional development	Metric met.	NA	NA

C. Additional Information

Copies of any of the assessment instruments or materials referenced in 4.A. and 4.B will be available for review at the time of the visit. Other information such as minutes from meetings where the assessment results were evaluated and where recommendations for action were made will also be included.