Metallurgical 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

This chapter describes the process for establishing student outcomes and revising them and the relationship of student outcomes to program educational objectives.

A. Process for the establishment and revision of the student outcomes

Program outcomes were established in 2002. Initially, the same (a)-(k) outcomes suggested by ABET were selected. Program faculty members attended numerous national assessment conferences and ABET seminars during that period so as to equip themselves with current ideas and best practices. During this period the initial (a)-(k) had grown to include several additional outcomes. Some outcomes such as communication were broken into two separate outcomes: oral and written. However, by the end of 2002, the need for such separations appeared weak and so was not adopted. Suggested new outcomes were also abandoned because they were found to be unrelated to a focused and systematic continuous improvement process. Consequently, the original (a)-(k) were adopted as the program outcomes. This selection is reviewed and discussed several times a year by program faculty, usually during the periodic outcome reviews. The same suggestions arise as were proposed in 2002 and are rejected for the same reasons they were rejected then.

Program faculty members remain vigilant through ABET seminars and by serving as continuous improvement consultants for new technical and societal trends that may need to be addressed by additional outcomes; however, none has risen to the level of importance warranting adoption. The program faculty members have always supported student's addressing economic, ethical, societal context, environmental, and safety issues but have embedded these into the design component of the current outcomes. These matters are now addressed in the revised (1) –(7) outcomes being proposed by ABET. This more formal collection of these topics is certainly agreeable to the program faculty members since it closely aligns with their practice and thinking.

Since 2002, the outcomes have been reviewed many times by the program faculty and the Metallurgical Engineering Advisor Board. Both the faculty and the board have ruled that the outcomes are appropriate and adequate within the requirements established by ABET. Now that ABET proposes to change the (a) – (k) requirements in a way that combines the elements of some of the (a) – (k) into new outcomes (1) – (7), the program faculty and the Advisory Board recommend adoption of that structural change and further have found at the March 2016 meeting that the (1) – (7) as proposed by ABET are adequate and appropriate. However, the current review is entirely based on the (a) – (k) outcomes.

B. Student outcomes

The Outcomes for the BS Metallurgical Engineering Program correspond to the criteria for accrediting engineering programs during the 2010 to 2015 accreditation cycle so no additional mapping is needed. These outcomes are shown in Table 3-1.

All program continuous improvement system (CIS) program documents are posted on the program CIS website: www.ABETMetEng.org/SD . This website reflects all of the program CIS documents, which reside on and are backed up on program computers. The website provides for selective controlled-user access. All program faculty members have complete download access to all CIS documents. The introduction of new documents to the CIS is controlled by the program designated CIS officer.

Table 3-1 Student Outcomes

a) Apply knowledge of mathematics, science, and engineering
b) Design and conduct experiments and analyze and interpret data
c) Design a system, component, or process with realistic economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints
d) Function on multidisciplinary teams
e) Identify, formulate, and solve engineering problems
f) Know professional and ethical responsibility
g) Communicate effectively
h) Know the impact of engineering on global, economic, environmental, and societal issues
i) Recognize the need for life-long learning
j) Know contemporary issues
k) Use the techniques, skills, and modern engineering tools necessary for engineering practice.

In addition to the (a) – (k) outcomes, the university has general education outcomes and measures of achieving their satisfaction. These measures have been improving over the last few years and are now at a point where the program plans to include them in them in the CIS beginning in 2016. The BS Metallurgical Engineering Program assesses on a calendar year basis; consequently, no reference is made to hyphenated academic years. The results of those measurements are included here to provide a view of the planned inclusion.

Student outcomes are posted on the department bulletin board located outside MI 114.

C. Relationship of student outcomes to program educational objectives

Table 3-2 shows the relationship of the metallurgical engineering program objectives to the program outcomes.

Table 3-2 The relationship between metallurgical engineering program objectives and program outcomes

Outcomes / Objectives	a	b	c	d	e	f	g	h	i	j	k
1 Apply Met Eng Prin.	■	■	■		■						
2 Meet Societal Needs								■		■	
3 Grow Prof & Personally.						■			■		■
4 Serve Comm. & Profession.				■		■	■			■	

Table 3-3 is a quality function deployment matrix (QFDM) that shows the relationship of curricular elements, which are shown along the top row, to the program outcomes, which are shown in the first column. A value of *9* indicates the curricular element is high important to the program outcome; whereas, a *1* indicates a low importance. No value indicates that there is no functional relationship. A non-linear scale (*0, 1, 3, 9*) is used to give emphasis to most important curricular elements since two elements rating 3 would not be as significant to achievement of a particular outcome as one element rated 9. Table 3-3 compares similar courses groups and also shows extra-curricular elements since the program graduate is formed by both course work and extra-curricular activities.

A second QFDM for specific courses in the metallurgical engineering program is shown in Table 3-4. In this case the highest rating is 5 rather than 9 because 0, 1, 3, and 5 ratings better describe the effect of coursework on each outcome since effect is somewhat related to time-in-class spent on each outcome. The table at the bottom indicates the total importance to program outcomes of each element. The last column shows the number of *high importance* elements (highest rated) for each outcome.

The QFDM is used to determine where in the curriculum action should be directed to achieve improvement in a particular outcome. Of course, this information also satisfies this element of the self-study.

Table 3-3 Quality function deployment matrix for metallurgical engineering curriculum

Desired Outcomes	**Processes**	Advising	Indiv. assistance	Met 351/352	Met 464/465	Scholarship program	Math sequence	H&SS curriculum	Lab curriculum	Met Eng (lecture)	Elective courses	out-of-dept tech elect	PE, Music, MS	Student org act	TLC	Library services	ENGL seq	Study groups	Met electives	Free electives	Chem/physics seq	Placement Prog
System will	Retain students	9	9			9		3	1		1	1	3	3	3			3		1		1
	Facilitate student employment	3	9			1		1	9	9	9	3	1	1		1	3		3			9
Graduates w	(a) Apply math, sci and eng prin		3	3	3		1		9	9	1	1				9		3	1	1	1	
	(b1) Design and Conduct experiments		3	3	3	1	9		3	9	3	1			3	1		1	3		3	
	(b) Analyze and interpret data and information		1	9	9		3	1	9	1						1			1		1	
	(c1) Optimally select material		1	9	3		3		9	9		1				1		1	1		3	
	(c2) Design materials treatment and production proc		1	9	9		1		1	3						1		1	3			
	(d) multidisciplinary teaming		1	9	9		1		1	3						1		1	3			
	(e) Ident, form, & solve eng prob	1		9	9			1	3	1			3	9			1		1		1	
	(f) Knowing prof and ethic respon		1	9	9		3		3	9	1			1		1			3		1	
	(g) communicate effectively	1	1	3	1			1		3						1			1			
	(h) impact of eng in a glob context		1		3		1	1	9	1							9	3	1			
	(i) Be life-long learner		1	3	3			9	1	3				1		1		1	1			
	(j) Know contemporary issues	1	1	1	1			1	9	1	2	1		1		9		1	3	9		
	(k) Use tech, skills, & mod tools		1					9		3				1		1			1			
	Use engineering techniques, skills, and tools (k)		3	1	1				9	3						1			1			
	LEGEND	15	37	68	63	11	22	27	76	67	17	8	7	17	6	29	13	15	27	11	10	10

9 High importance
3 Medium Importance
1 Low Importance
No importance

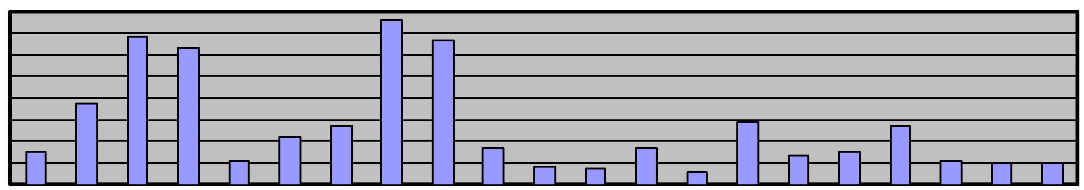
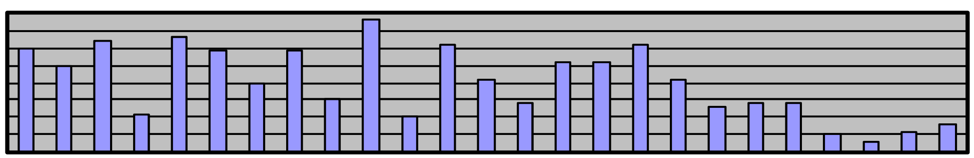


Table 3-4 Quality function deployment matrix for metallurgical engineering courses

Outcome Criteria	**Course**																								
	MET 220	MET 220L	MET 231	MET 232	MET 310	MET 310L	MET 320	MET 321	MET 330	MET 330L	MET 332	MET 351/352	MET 422	MET 433	MET 440	MET 440L	MET 464/465	MET Electives	Math sequence	Required Eng Courses	H&SS curriculum	Elective Courses	PE, Music, Band, MS	ENGL Sequence	Chem/Physics Seq
(a) Apply mathematics, science and engineering principles	5	3	3	5	5	3	5	3	5	5	5	1	5	5	3	3	1	3	5	5		3			3
(b) Ability to design and conduct experiments and interpret data	3	5	5		3	5	3	3	3	5		1	3		3	5	1	3	3						3
(c) Ability to design a system, component, or process to meet design needs	3			3	3	3	3	5				5	5	3	3	3	5	3	1						
(d) Ability to function on multidisciplinary teams	1	3	5		1	1				5		5			1	3	5	1			1		3	1	1
(e) Ability to identify, formulate, and solve engineering problems	5	3	3	3	3	3	3	5	5	5	5	5	5	1	5	3	5	3	3	5		1			1
(f) Understanding of professional and ethical responsibility	3	1	1		3	1	1	5	1	3		3			3	1	3	1			1				
(g) Ability to communicate effectively	3	5	3		3	5	1	3		3		5			3	5	5	1	1		1			5	
(h) The broad education necessary to understand the impact of engineering solutions in a global	3		5		3	1	1			3								1		1	5				
(i) Recognition of the need for and an ability to engage in life-long learning			3		3	1				3		1			1		1	3			1	1			
(j) Knowledge of contemporary issues	3		1		1	1		5	1	1					1			1			5				
(k) Ability to use the techniques, skills, and modern engineering tools necessary for	1	5	3		5	5	3			5		5	3	5	3	3	5	1		3					
	30	25	32	11	33	29	20	29	15	38	10	31	21	14	26	26	31	21	13	14	14	5	3	6	8

LEGEND

5 High importance
3 Medium Importance
1 Low Importance
No importance



CRITERION 4 - CONTINUOUS IMPROVEMENT

This chapter contains information on the Continuous Improvement System (CIS) developed and employed by the BS. Met Engineering Degree Program

A. Student outcomes

The student educational was reviewed by program faculty and the department's Advisory Board and upheld as appropriate during the period 2009-2016.

a) Apply Knowledge of Math, Science, and Engineering
b) Design and Conduct Experiments and Analyze and Interpret Data and Information
c) Optimally Select Material and Design Materials Treatment and Production Processes
d) Function Well on Teams
e) Identify, Formulate, and Solve Engineering Problems
f) Know Professional and Ethical Responsibilities and Practices
g) Communicate Effectively
h) Know Engineering's Global Societal Context
i) Engage in Life-Long learning
j) Know Contemporary Issues
k) Use Engineering Techniques, Skills, and Tools

B. Continuous improvement

The BS Metallurgical Engineering Program has employed a Continuous Improvement System (CIS) since 1970. Since 2003 all of the routine tabulation and presentation of results are performed by Excel VBA MACRO automation and posted at www.ABETMetEng.org. This makes all CIS results and data easily available to program faculty, administrators, students, Advisory Board members, and other interested parties at any time. For the ABET visit all CIS documents will be available in hard copy. This Self Study Report contains pertinent summary data and examples of collection documents so that the Program Evaluator will have clear understanding of what documents and records are available for detailed inspection. The CIS process is shown in Figure 4-1. The upper part of the figure shows the process for the continuous evaluation of program objectives, no longer required by ABET, while the lower half shows the process for outcome assessment.

The Metallurgical Engineering Department does not view operating the CIS as an ABET requirement but rather are of the position that ABET requirements will be met as a consequence of the department's long-established CIS system. Of course, the system has been modified over the years to meet ABET's interests and requirement for the sake of efficiency. ABET's discontinuance of Program Objective Evaluation since the last visit would not mean that the program would discontinue that long-established endeavor in the CIS program. Therefore, diagrams such as Figure 4-1 may show processes beyond the scope of the ABET review but are, nevertheless, an integral part of the program's Continuous Improvement System.

Next, the system for assessing outcomes (e.g. - student educational outcomes) will be discussed. Before presenting the details of the assessment process, it should be noted that the CIS keeps no

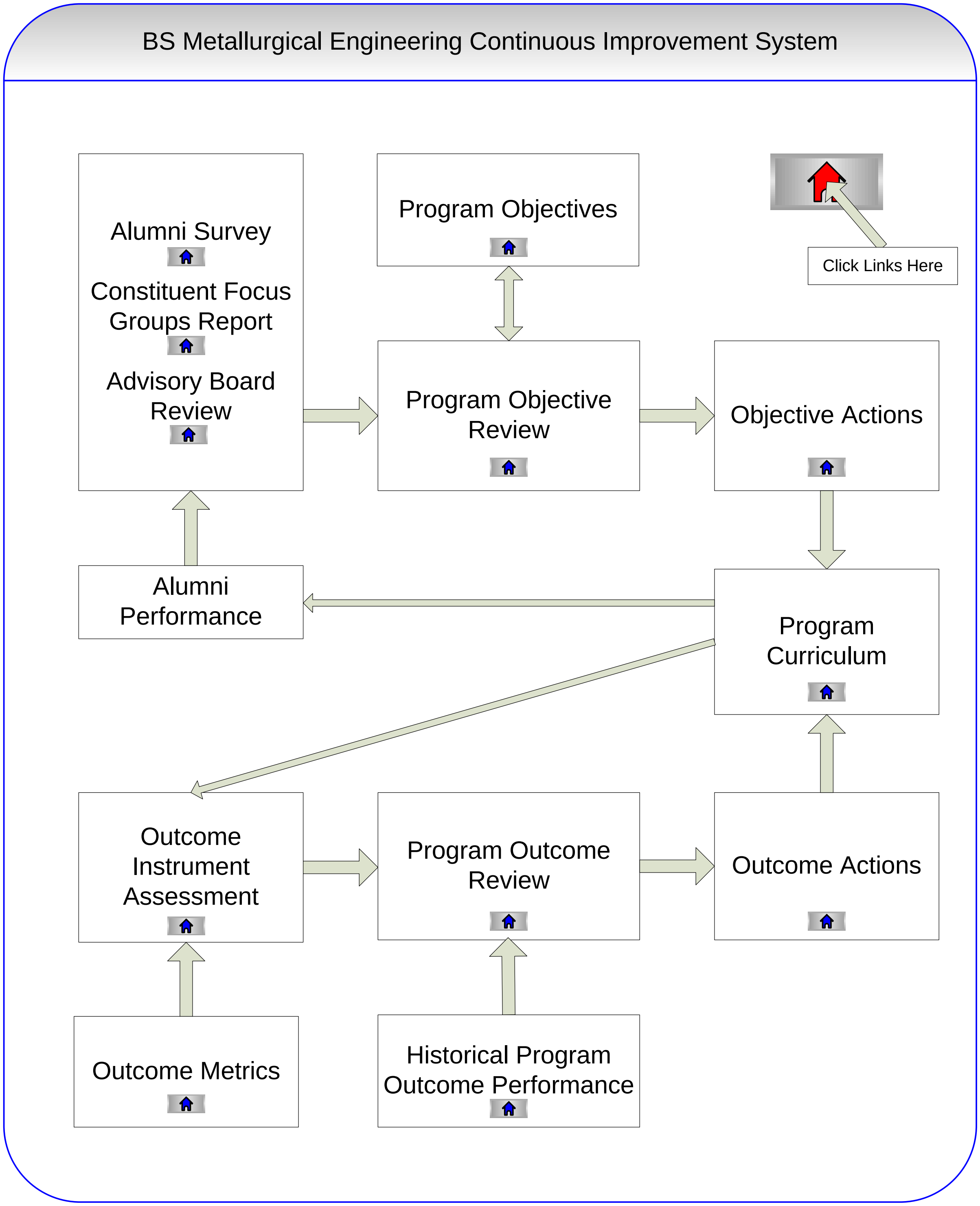


Figure 4-1 – The BS Metallurgical Engineering Continuous Improvement System data by academic year, because using the historical academic year referencing proved very confusing, was the source of many time-consuming recording errors, and stymied clarity in discussions of curriculum among program faculty. Consequently, all dates in the CIS are strictly calendar year style and everything in the CIS runs by calendar year and has since 2003.

Figure 4-2 shows the Annual Assessment cycle starting in January.   The annual reviews of the calendar year's assessments are completed in the early part of the spring semester and necessary changes to curriculum are made. Changes in curriculum are planned and implemented for the next course offerings. In some cases, those are implemented immediately, but the great majority of changes, the remainder of the spring semester and the summer is available to implement the modifications. Changes occurring immediately are usually anticipated from the results of the previous spring semester interim assessments and so spring semester course syllabi are able to accommodate such adjustments. Experience shows that it is less efficient to implement changes in the summer break, because there is less faculty availability during the summer than during the winter break since faculty are salaried for academic curriculum work during the winter semester break but not during the summer break.

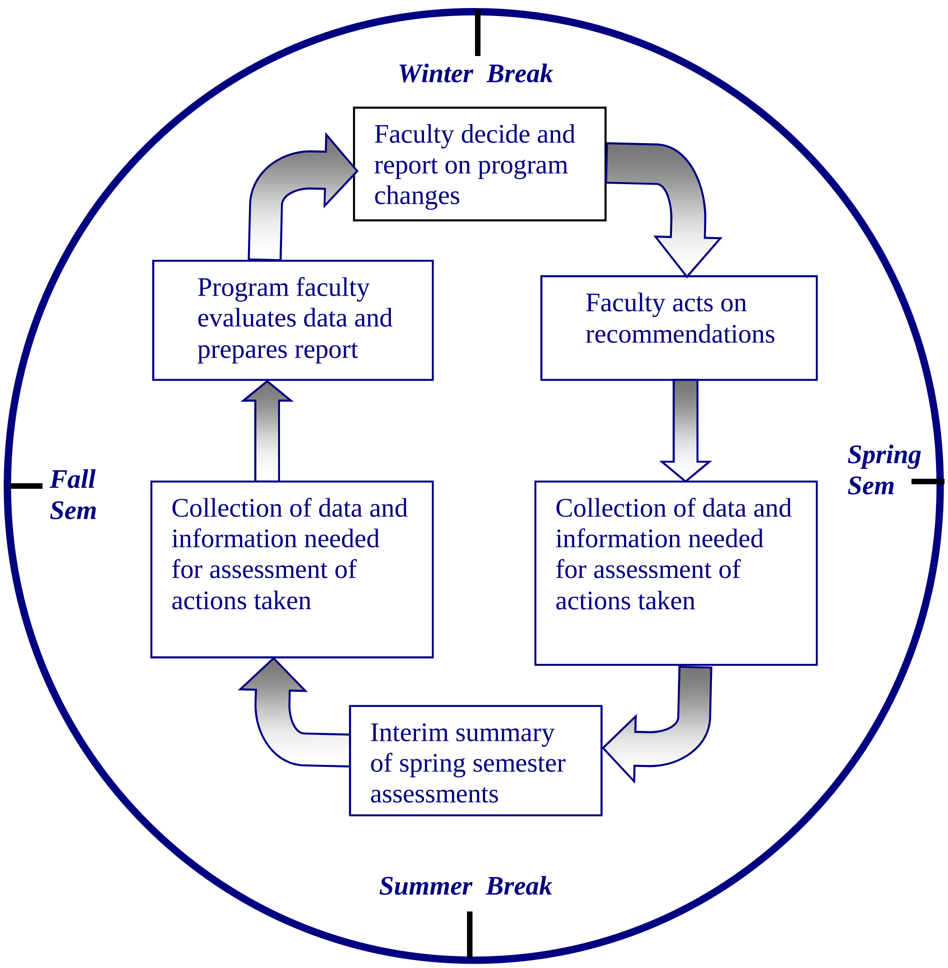


Figure 4-2 - The Annual Cycle of Outcome Assessment and Evaluation

Before describing the CIS system, a description of terms is in order.

Program Educational Objectives: Information for program educational object evaluation is derived from meetings with the Advisory Board, surveys of alumni, and meetings with constituent focus groups. The reports from these groups and the surveys and the program review including actions and accomplishments are stored digitally in the Continuous Improvement System (CIS) computers and uploaded to the CIS website. Access to these files may be attained by contacting Dr. Michael West, Head, Department of Materials and Metallurgical Engineering.

Program Outcomes: Information for the program outcomes is derived from a wide range of sources (called instruments), including student work, presentations, surveys, exams, etc. To the extent that the source of the information is concrete (viz.-student reports, homework), it is stored in hard copy form in the CIS Archive located in the departmental office, MI 115. Currently, these files fill a file cabinet in MI 115. Each of these archival records is accompanied by its score card onto which assessment scores are recorded. When abstract information is used to assess outcomes (viz.- presentations, design fairs), the score cards completed by the assessor are filed in the CIS hard copy archives often with a summary document describing the instrument. All of the score card information is recorded and rendered into summary format digitally and uploaded onto the CIS website. Any file requested by the program evaluator will be available in hard copy at the time of the visit.

To assist the program evaluator in finding and indicating the documents need to review the program's processes, a summary of its salient elements are listed in Table 4-1 in the order in which information flows for outcome assessment. Each of the items in the table is a document except for abstract instruments such as an oral presentation. Figure 4-3 shows the flow of assessment elements in the CIS. The entire process begins with the Instrument Inventory. There is an Instrument Inventory for each calendar year. It contains a listing of all instruments used for the entire assessment of Outcomes (a – k). Table 4-2 shows the 2015 Instrument Inventory. The inventory consists of instruments that encompass a range of assessment methodologies as described in the headers in columns two through four: Method 1 - *Archival Records/Portfolios*; Method 2 - *Standardized Exams, Simulations, Performance Appraisals, External Examiner, and Oral Exam*; and Method 3 - *Surveys, Exit Interviews*. Using a range of method provides for assessment triangulation that mitigates the effects and identifies the question use of biased methodology.

The inventory is used to automatically generate score cards for each instrument. Figure 4-4 shows a typical score card. There are specific metrics for assessment of each (a-k) outcome. Example metrics are shown in Table 4-3. For each metric there is column on the score card to record assessment results, which consist of a 1, 3, or 5 corresponding to poor, moderate, and high achievement.

The results for each score cards for one year and for one outcome are summarized on an Outcome Summary an example of which is shown in Table 4-4. The outcome summaries are consolidated the Assessment Summary, which shows all outcome results for one year. Table 4-5 shows an example Assessment Summary. Assessment summaries are consolidated over the

Table 4-1 Elements of CIS Outcome Assessment

Instrument	The collection of a specific document, one per student or team, used to assess a Program Outcome. Examples of the specific document may be a completed homework assignment or an exam, faculty member-completed oral presentation assessment form, or students' standardized exam results.
Score Card	A Microsoft Excel® table document on which the Program Outcome assessment results for one instrument are recorded. These are typically completed by one designated faculty assessor.
Outcome Summary	A Microsoft Excel® table document for a specified Program Outcome onto which the all the score card assessment results for the specified outcome are summarized and tabulated for one calendar year.
Assessment Summary	A Microsoft Excel® document consisting of a Table and a Chart onto which all Program Outcomes results are organized for one academic year.
Grand Summary	A Microsoft Excel® document that shows the assessment results for all outcomes for all years, any one outcome over time, or all outcomes for any selected year.
Outcome Review	A Microsoft Excel® worksheet onto which a designated metallurgical engineering faculty member documents his critical review of a selected Program Outcome for a specified academic year and includes actions needed.
Outcome Review Summary	A Microsoft Excel® worksheet that contains a complete sequential history of the evaluation, actions, and results for one Outcome Review for all years.

years into what is called the Grand Summary. The Grand Summary is a bar chart that shows all the annual results for each outcome over time: a summary of all Assessment summaries. Figure 4-5 shows the Grand Summary for the period 2004 through the last completed assessment year, 2015. Since the CIS is a web-based system, there are many other data presentation and viewing configurations available to the user, but those are of peripheral importance to the Self Study Report so are not described here.

Average outcome assessment showing student achievement above 4.0 is considered to be satisfactory warranting no corrective action. A continuing or trending downward to an average outcome assessment below 3.5 is of great concern and requires action. A watch is usually issued for possible transient moves below 3.5. If the low performance persists, an action is needed. For performance between 3.5 and 4.0, a watch is invoked most often. However, depending on faculty workload and status, actions may be imitated for outcomes scoring in the 3.5 to 4.0 range. Faculty status includes such things as the level of key faculty experience for a particular outcome. That is, new faculty would be expected to improve as they gain experience. This could affect the construction of questions used in archival work used for assessment, their assessment of instruments used in CIS, as well as their instructional effectiveness. These are all considered when deciding on when to initiate an action.

In the CIS the word *review* is used to determine what action is taken based on the Outcome Summary. (The word *evaluation* is used to describe program objectives information processing

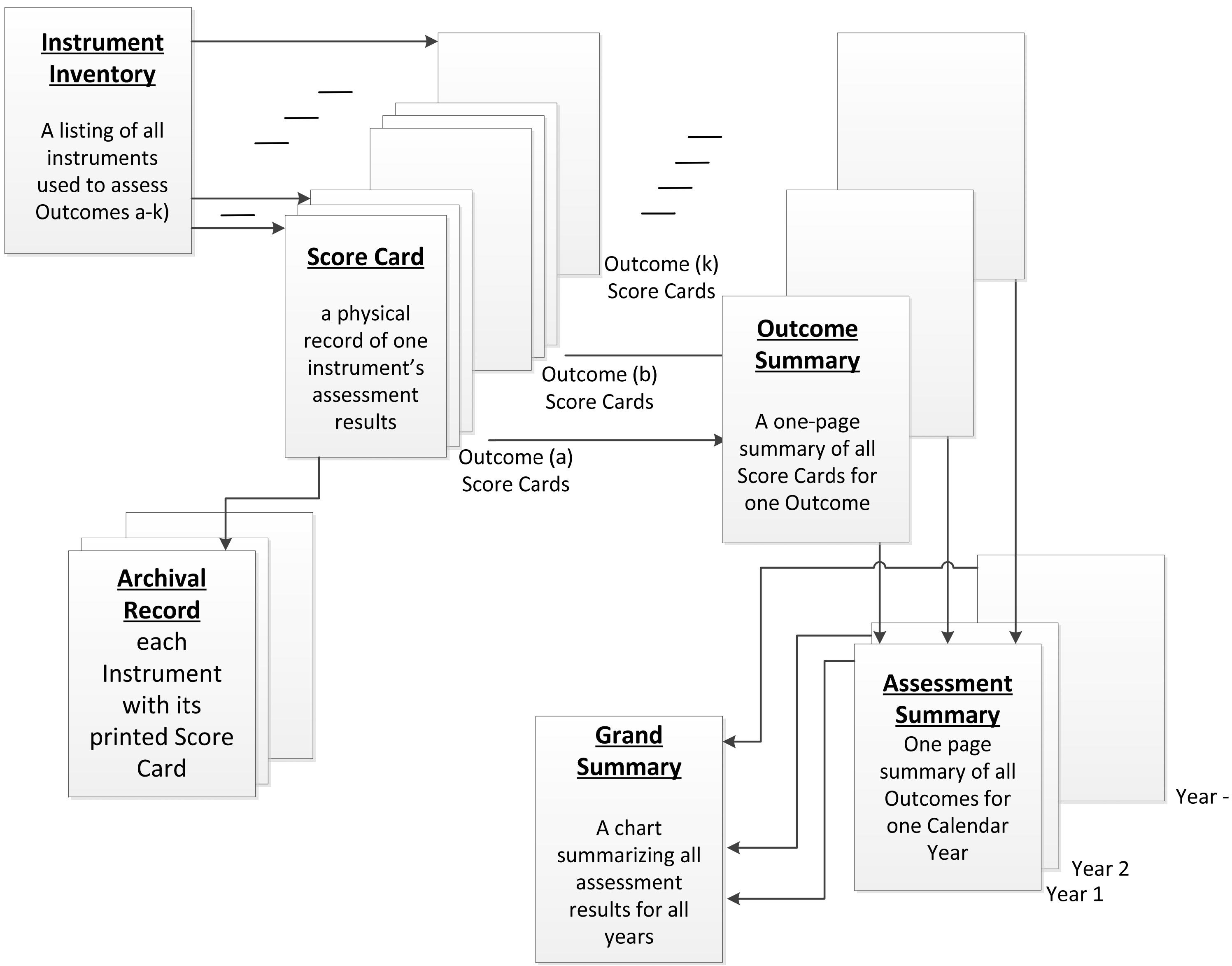


Figure 4-3 Schematic of the CIS Assessment Process Records

Table 4-2 Instrument Inventory for 2015

Outcome Assessment Plan - Instrument Inventory			**2015**
Criteria	**Method 1** Archival Records/Portfolios	**Method 2** Standardized Exams, Simulations, Performance Appraisals, External Examiner, and Oral Exam.	**Method 3** Surveys, Exit Interviews
a Apply knowledge of math, science, and engineering	**MET 320** - (F) . Final Exam **MET 330** - (F-odd) . Final Exam **MET 332** - (F-odd) . Final Exam	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
b Design and conduct experiments Analyze and interpret data and information	**MET 330** - (F-odd) . Tool Lab **MET 231** - (S or F) . Hardness and Statistics Labs	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
c Optimally select material and design materials treatment and production processes	**MET 465 - (S)** **. Final Design Report** **MET 465 - (S)** . Design Fair Presentation Evaluations	**MET 465 - (S)** **. Local Exam**	**MET 465 - (S)** **. Senior Survey**
d Function well on teams	**MET 465** - (S) . Final Design Report	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
e Identify, formulate, and solve engineering problems	**MET 321** - (S-odd) . Final Exam (or All Exams)	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
f Know professional and ethical responsibilities and practices	**MET 465** - (S) . Final Design Report	**MET 465** - (S) . Local Exam	**MET 465 - (S)** . Senior Survey
g Communicate effectively	**MET 231** - (S or F) . Charpy Impact Lab **MET 330** - (F-odd) . Student Choice Lab Report **MET 465** - (S) . Final Design Report **MET 465** - (S) . Design Fair Presentation	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
h Know engineering's global societal context	**MET 321** - (S-odd) . Pyromet Processing Issues **MET 465** - (S) . Design Report Global-Societal Considerations	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey

Table 4-2 Instrument Inventory for 2015 (cont'd)

i Engage in life-long learning	**MET 321** - (S-odd) . Cognitive Devel Writing Assignment	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
j Know contemporary issues	**MET 321** - (S-odd) . Pyromet Processing Issues	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey
k Use engineering techniques, skills, and tools	**MET 220** - (S) . Microtrack Lab Report **MET 320** - (F) . ThermoCalc **MET 321** - (S-odd) . Excel Worksheets	**MET 465 - (S)** . Local Exam	**MET 465 - (S)** . Senior Survey

rather than outcomes.) As show in Figure 4-2, the program faculty members meet and review the performance of the students as measured by the assessment of the instruments in the inventory.

The usual practice (except for training new faculty) is for each Outcome Summary to be reviewed by a single faculty member. The result of the review is a completed Review an example of which is shown in Figure 4-6. The final step in the review process is for the entire teaching faculty to review all decisions and agree on any needed remedial courses of action. Of course the action is then implemented into the curriculum of the assessment process as needed.

The review process may take into consideration as much additional information as the reviewer deems necessary. Certainly the review must take into consideration the previous year's recommendations, if any. If the results show consistently high performance, there may be no need to look further into the results; however, large differences in scores among outcomes may require additional analysis. Each review always consists of two parts: 1) review of curricular effectiveness based on assessed student performance and 2) assessment of the functioning of the assessment system. The former having implications on curricular change while the latter suggests changes in the means of measurement.

Every review of each outcome each year results in one of four possible entries being placed on the review form for both the curriculum and the system review: N, W, A, or C denoting the following:

- N - No action
- W - Watch for possible future action
- A - Action
- C - Comment

The last three entries require a written input in the action table on the review form. If no action is needed, no further description is required. The review form shows the previous year's summary statements and requires a summary statement be entered for the current year. These statements may be thought of as *start-of-the-year* and *end-of-the-year* statements or, if an action was required, *actions needed* and *results achieved.* Table 4-6 shows an example summary of all reviews called a Review Summary for all specified years for one outcome. A Review Summary is available for each outcome in Appendix E.

2015 Outcome Score Card | **(a)** | *(a) Apply knowledge of math, science, and engineering*

MET_332
FinalExam

☐ Check Here if Teams

Rate the performance using
1 Lowest
5 Highest

Do not change file name

Leave metric column blank if it does not apply.

Enter your initials and date.

Team / Student	Proficient in Fundamental Concepts and Skills	Proficient in Theoretical and Practical Relationships	Proficient in Basic Science	
Max	**5.00**	**5.00**	**5.00**	
Ave	**3.26**	**3.82**	**3.62**	
Min	**1.00**	**1.00**	**1.00**	
1	1	1	1	
2	3	5	5	
3	5	3	3	
4	1	1	3	
5	3	3	5	
6	1	1	1	
7	3	5	3	
8	3	3	3	
9	5	5	5	
10	5	5	5	
11	5	3	5	
12	3	5	3	
13	5	3	5	
14	3	3	1	
15	3	5	5	
16	3	3	5	
17	3	3	3	
18	3	3	5	
19	3	5	5	
20	5	5	5	
21	3	3	5	
22	3	5	3	
23	3	1	3	
24	3	5	3	
25	3	5	5	
26	1	5	3	
27	3	1	1	
28	3	5	5	
29	5	5	1	
30	3	3	1	
31	5	5	3	
32	5	5	3	
33	3	5	5	
34	3	5	3	
35	5	5	5	
36	1	5	3	
37	1	3	5	
38	3	3	5	
39	5	5	3	
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				

Notes

Method	1
Count	117
Assessor's Initials	MW
Date	12/19/2015

Figure 4-4 –Score Card for Outcome (a) 2015, MET 332 Final Exam example

Table 4-3 Metrics for Outcome (a) example

Metric Title	(a) Apply Knowledge of Math, Science, and Engineer		
Performance Criteria	**Low Performance:1**	**Moderate Performance:3**	**Exemplary Performance:5**
Proficient in Fundamental Concepts and Skills	· No application of statistics to analysis of data · No use of math software · Calculations not performed or performed incorrectly by hand · Mathematical terms are interpreted incorrectly or not at all · Does not understand the application of calculus and linear algebra in solving engineering problems	· Minor errors in statistical analysis of data · Some use of math software · Minor errors in calculations by hand · Most mathematical terms are interpreted correctly · Shows nearly complete understanding of applications of calculus and/or linear algebra in problem-solving	· Correctly analyzes data sets using statistical concepts · Uses mathematical software · Executes calculations correctly by hand · Translates academic theory into engineering applications and accepts limitations of mathematical models of physical reality · Shows appropriate engineering interpretation of mathematical and scientific terms
Proficient in Theoretical and Practical Relationships	· Does not appear to grasp the connection between theory and the problem · Does not understand the connection between mathematical models and chemical, physical, and/or in engineering systems	· Some gaps in understanding the application of theory to the problem and expects theory to predict reality · Chooses a mathematical model or scientific principle that applies to an engineering problem, but has trouble in model development	· Translates academic theory into engineering applications and accepts limitations of mathematical models of physical reality · Combines mathematical &/or scientific principles to formulate chemical and physical models for relevant to engineering
Proficient in Basic Science	Student applies basic science concepts as minimal components of work or has major misconceptions.	Student applies concepts from basic science as significant components of work with few errors.	Student applies concepts from basic science as essential components of work with virtually no conceptual errors.

Table 4-4 Outcome Summary (a) 2015 example

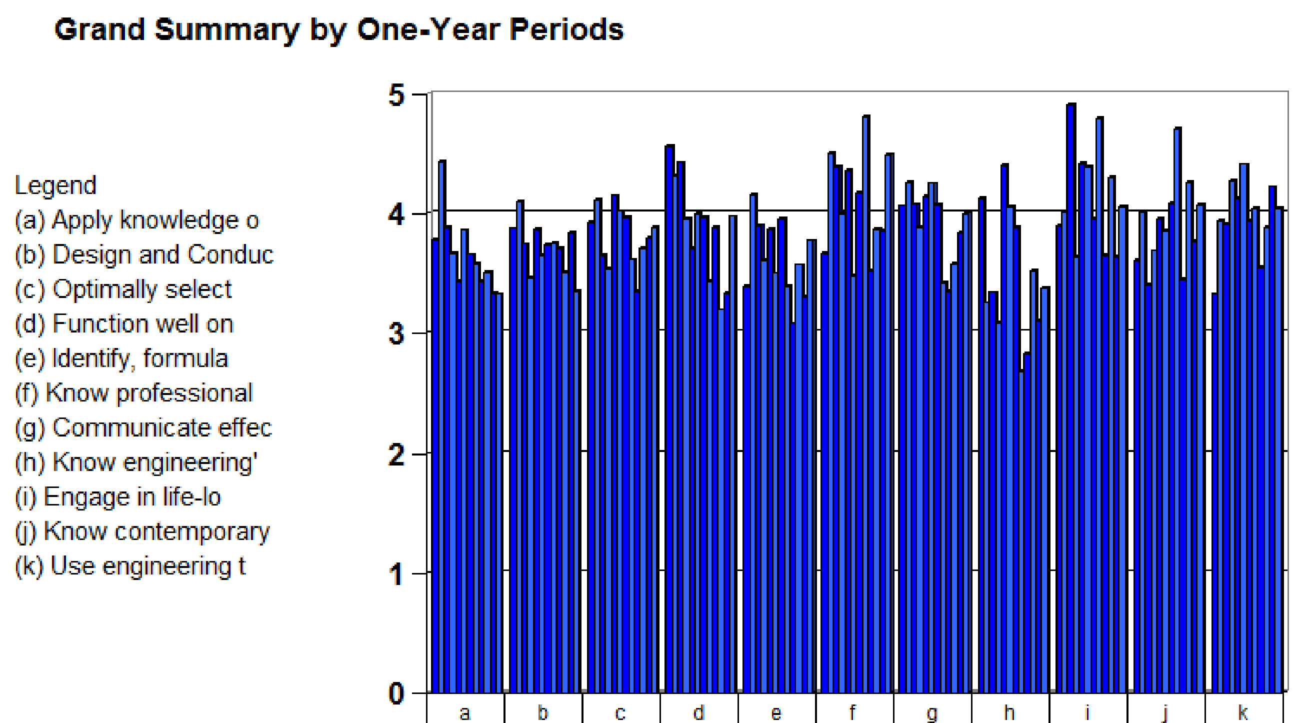
Outcome Summary				**2015**	*(a) Apply knowledge of math, science, and engineering*			
		Average Summary 324 # Assessments 11 # Averages		***Max***	4.14	3.82	3.62	
				Ave	3.48	3.22	3.26	
				Min	2.74	2.69	2.74	
Instrument					Proficient in Fundamental Concepts and Skills	Proficient in Theoretical and Practical Relationships	Proficient in Basic Science	
MET_320								
(a) FinalExam		1	Method	**Max**	5.00			
SMH		36	# Assessments	**Ave**	3.61			
12/21/15				**Min**	1.00			
MET_330								
(a) FinalExam		1	Method	**Max**	5.00	5.00	5.00	
GAC		117	# Assessments	**Ave**	2.74	2.69	2.74	
12/29/15				**Min**	1.00	1.00	1.00	
MET_332								
(a) FinalExam		1	Method	**Max**	5.00	5.00	5.00	
MW		117	# Assessments	**Ave**	3.26	3.82	3.62	
12/19/15				**Min**	1.00	1.00	1.00	
MET_465								
(a) LocalExam		2	Method	**Max**	5.00			
SMH		12	# Assessments	**Ave**	3.67			
6/6/15				**Min**	1.00			
MET_465								
(a) SeniorSurvey		3	Method	**Max**	5.00	5.00	5.00	
SEN		42	# Assessments	**Ave**	4.14	3.14	3.43	
1/20/16				**Min**	3.00	3.00	3.00	

Table 4-5 Assessment Summary 2015 example

Outcome	Description	Performance Objective 1	Performance Objective 2	Performance Objective 3	Performance Objective 4		
a	(a) Apply knowledge of math, science, and engineering	Proficient in Fundamental Concepts and Skills	Proficient in Theoretical and Practical Relationships	Proficient in Basic Science		Instrument Average	
#Totals		4.14	3.82	3.62		Max	3.48
324		3.48	3.22	3.26		Ave	3.32
11		2.74	2.69	2.74		Min	3.22
b	(b) Design and Conduct experiments Analyze and interpret data and information	Conducts the design of experiments.	Operates equipment and collects data for analysis.	Compares results for experimental measurements to the literature and conducts interpretation of results in written reports.	Is able to collect global information and to use this information in evaluation and interpretation of laboratory data	Instrument Average	
#Totals		3.57	4.57	4.29	3.75	Max	3.77
106		2.84	3.77	3.51	3.23	Ave	3.34
11		1.67	3.00	3.00	2.71	Min	2.84
c	(c) Optimally select material and design materials treatment and production processes	Understand the engineering design process	Formulate possible engineering solutions	Master the iterative process in engineering design	Recognize and observe constraints in engineering design	Instrument Average	
#Totals		4.14	3.75	4.21	4.00	Max	4.00
100		3.91	3.75	3.86	4.00	Ave	3.88
8		3.75	3.75	3.50	4.00	Min	3.75
d	(d) Function well on teams	Responsible Participation	Interaction Skills	Assimilation and Receptiveness Skills		Instrument Average	
#Totals		4.43	4.29	3.75		Max	4.14
64		4.14	4.02	3.75		Ave	3.97
6		4.00	3.75	3.75		Min	3.75
e	(e) Identify, formulate, and solve engineering problems	Identify	Formulate	Solve		Instrument Average	
#Totals		4.43	4.07	4.03		Max	4.05
155		3.31	4.05	3.95		Ave	3.77
7		2.66	4.03	3.86		Min	3.31
f	(f) Know professional and ethical responsibilities and practices	Carries out responsibilities in a professional and ethical manner	Understands basic engineering principles and practices, in terms of professional ethics and behavior			Instrument Average	
#Totals		4.57	4.75			Max	4.66
56		4.30	4.66			Ave	4.48
5		3.83	4.57			Min	4.30

Table 4-5 Assessment Summary 2015 example (cont'd)

g	(g) Communicate effectively	The content of the written or oral presentation is effective.	The organization of memorandum and technical reports is consistent with styles accepted by the person's primary professional engineering society.	The design of slides shows an understanding of vision limitation of the audience and the total time the presenter plans to spend on the visual aid during oral presentations.		Instrument Average	
#Totals		5.00	4.29	4.43		Max	4.19
118		4.07	3.73	4.19		Ave	4.00
13		3.29	2.71	3.90		Min	3.73
h	(h) Know engineering's global societal context	Has the broad education necessary to understanding impact of engineering solutions in global and societal context	Awareness of contemporary state of knowledge and relationship to engineering solutions	Recognizes the need to be aware of societal issues especially those that can be engaged by engineering solutions		Instrument Average	
#Totals		4.67	3.86	3.00		Max	3.84
76		3.84	3.26	3.00		Ave	3.37
7		3.00	2.75	3.00		Min	3.00
I	(i) Engage in life-long learning	Ability to adapt to changing technology.	Understanding of the need to continually update one's skills and knowledge.	Cognitive Level Assessment		Instrument Average	
#Totals		4.38	4.43	3.83		Max	4.30
104		4.02	4.30	3.83		Ave	4.05
6		3.83	4.17	3.83		Min	3.83
j	(j) Know contemporary issues	Ability to identify basic problems and contemporary issues in engineering.	Application of knowledge of contemporary issues to Metallurgical Engineering			Instrument Average	
#Totals		4.33	4.14			Max	4.15
64		4.15	3.99			Ave	4.07
5		3.83	3.83			Min	3.99
k	(k) Use engineering techniques, skills, and tools	Capable of using tools such as Excel, SolidWorks, MathCAD ---	Proficient in operating equipment used in the laboratory program such as the MTS machine, rolling mill, hardness tester ---	Understands the engineering design method and can apply this method in developing solutions to engineering problems.		Instrument Average	
#Totals		4.50	4.43	4.43	4.26	Max	4.26
168		4.24	3.71	3.91	4.26	Ave	4.03
10		3.80	3.00	3.40	4.26	Min	3.71



	a	b	c	d	e	f	g	h	i	j	k
2004	3.77	3.87	3.92	4.55	3.38	3.67	4.06	4.13	3.89	3.60	3.32
2005	4.42	4.09	4.11	4.31	4.15	4.50	4.25	3.25	4.00	4.00	3.93
2006	3.88	3.74	3.65	4.42	3.90	4.39	4.07	3.34	4.90	3.40	3.90
2007	3.66	3.45	3.53	3.95	3.61	3.99	3.88	3.08	3.64	3.68	4.26
2008	3.43	3.87	4.14	3.70	3.86	4.35	4.14	4.40	4.41	3.95	4.12
2009	3.86	3.64	4.01	3.99	3.50	3.48	4.24	4.05	4.39	3.85	4.40
2010	3.65	3.73	3.96	3.97	3.95	4.17	4.07	3.88	3.94	4.08	3.93
2011	3.58	3.75	3.61	3.43	3.38	4.80	3.42	2.68	4.79	4.70	4.03
2012	3.43	3.70	3.34	3.87	3.08	3.52	3.35	2.82	3.65	3.45	3.54
2013	3.50	3.51	3.71	3.19	3.57	3.87	3.57	3.51	4.29	4.25	3.88
2014	3.33	3.83	3.79	3.33	3.29	3.85	3.83	3.09	3.63	3.77	4.22
2015	3.32	3.34	3.88	3.97	3.77	4.48	4.00	3.37	4.05	4.07	4.03

Figure 4-5 Grand Summary of assessment results 2004-2015

Outcome Review

2015	(a) Apply knowledge of math, science, and engineering	Reviewer	
		Date	

Instruments for Review

Course	Instrument	Unused
MET_320	(a) FinalExam	
MET_330	(a) FinalExam	
MET_332	(a) FinalExam	
MET_465	(a) LocalExam	
MET_465	(a) SeniorSurvey	

Reviews

Curriculum

Previous Curriculum Action Review Summary

The average score has dropped to 3.3 from 3.50. This drop is reflected in the non-subjective Exit exam scores, too. Therefore, it appears to be a real decrease unrelated to reviewer subjectiveness. Some Action is needed to determine the cause of this decrease. One item that should be reviewed is average class GPA.

Curriculum Review Summary

The average score has remained low and is reflected in the non-subjective decreasing Senior Exit Exam scores from 2010 to 2015: 4.67, 4.71, 4.60, 3.78, 3.55, 3.67. It seems very unlikely this drop is the result of variations in student learning but rather because something has changed in the assessment methodology. Therefore, action is focused on assessment processes. Otherwise, a review of basic (Freshman & Sophomore) science and math instruction will be needed but only if other programs note the same decrease.

Code	*Curriculum Action Title*	*Curriculum Action Brief Description*
W	Low a) watch	If there is no improvement in a) assessments, a review of instructional methods is needed.

Assessment Process

Previous Assessment Process Action Review Summary

Continue the Watch from 2013 per 2-year cohort system.

Assessment Process Review Summary

The results from MET 330 remain significantly lower than from other instruments. Conduct training and review on a) Metrics for faculty members.

Code	*Assessment Process Acti*	*Assessment Process Action Brief Description*
A	Metrics Training and Review	Conduct a comparative review of a) outcome metrics and procedures.
A	Increase Senior Exam Prestige	Move the exit exam to earlier in the semester and have the Dept Head administer the testing.

Figure 4-6 Example review of Outcome (a): 2015

Table 4-6 Review Summary for Outcome (a) example

2010

Previous Curriculum Action Review Summary

Mean Student performance improved from 2008 to 2009, while the variation betweeninstruments was considerably reduced. MATH 373 has ceased being a useful assessment tool.

Curriculum Review Summary

Math 373 was removed and not considered as an assessment tool for 2010.

Code	*Curriculum Action Title*	*Curriculum Action Brief Description*
N		

Previous Assessment Process Action Review Summary

As previously, all student assessments for the local exam were the same. They were all very good, but with no variation. This may indicate some changes in questions or how the scores are apportioned is needed. No results were returned for MATH 373. Scores have stabilized so the extra faculty training is likely having an effect.

Assessment Process Review Summary

MATH 373 has been removed. Significant variability in 2010 was observed. However, much of the variability can be related to less number of students taking the FE Exam. So the watch has been removed.

Code	*Assessment Process Action Title*	*Assessment Process Action Brief Description*
N		

2011

Previous Curriculum Action Review Summary

Math 373 was removed and not considered as an assessment tool for 2010.

Curriculum Review Summary

The outcome review scores were consistent with the previous year and therefore no action is needed.

Code	*Curriculum Action Title*	*Curriculum Action Brief Description*
N		

Previous Assessment Process Action Review Summary

MATH 373 has been removed. Significant variability in 2010 was observed. However, much of the variability can be related to less number of students taking the FE Exam. So the watch has been removed.

Assessment Process Review Summary

The variability in 2011 has been decreased when compared to previous year. Therefore no action is needed.

Code	*Assessment Process Action Title*	*Assessment Process Action Brief Description*
N		

2012

Previous Curriculum Action Review Summary

The outcome review scores were consistent with the previous year and therefore no action is needed.

Curriculum Review Summary

The outcome review scores were consistent with the previous year. Therefore no action is needed

Code	*Curriculum Action Title*	*Curriculum Action Brief Description*
N		

Previous Assessment Process Action Review Summary

The variability in 2011 has been decreased when compared to previous year. Therefore no action is needed.

Assessment Process Review Summary

The variability has been decreased when compared to 2011. Much of the variability can be related to number of students taking the FE Exam.

Code	*Assessment Process Action Title*	*Assessment Process Action Brief Description*
N		

Table 4-6 Review Summary for Outcome (a) example (cont'd)

2013

Previous Curriculum Action Review Summary

The outcome review scores were consistent with the previous year. Therefore no action is needed

Curriculum Review Summary

The outcome review scores were consistent with 2012; therefore, no action is needed.

Code	Curriculum Action Title	Curriculum Action Brief Description
N	No Action	

Previous Assessment Process Action Review Summary

The variability has been decreased when compared to 2011. Much of the variability can be related to number of students taking the FE Exam.

Assessment Process Review Summary

The average of 3.50 was the same as the previous year. There seems to be a trend downwards; however, one reviewer scored student performance particularly low in one course. It is recommended that a watch be placed on this item to determine if the low ratings remain reviewer specific and if so then seek more uniform assesment methods.

Code	Assessment Process Action Title	Assessment Process Action Brief Description
W	Instrument Scoring Variability	Determine if the the MET 330 instrument yields low scores in 2015.

2014

Previous Curriculum Action Review Summary

The outcome review scores were consistent with 2012; therefore, no action is needed.

Curriculum Review Summary

The average score has dropped to 3.3 from 3.50. This drop is reflected in the non-subjective Exit exam scores, too. Therefore, it appears to be a real decrease unrelated to reviewer subjectness. Some Action is needed to determine the cause of this decrease. One item that should be reviewed is average class GPA.

Code	Curriculum Action Title	Curriculum Action Brief Description
A	Remedy Low a)	Administer Exit exam in a more formal setting so as to make it appear more important to students.

Previous Assessment Process Action Review Summary

The average of 3.50 was the same as the previous year. There seems to be a trend downwards; however, one reviewer scored student performance particularly low in one course. It is recommended that a watch be placed on this item to determine if the low ratings remain reviewer specific and if so then seek more uniform assesment methods.

Assessment Process Review Summary

Continue the Watch from 2013 per 2-year cohort system.

Code	Assessment Process Action Title	Assessment Process Action Brief Description
W	Instrument Scoring Variability	Determine if the the MET 330 instrument yields low scores in 2015.

2015

Previous Curriculum Action Review Summary

The average score has dropped to 3.3 from 3.50. This drop is reflected in the non-subjective Exit exam scores, too. Therefore, it appears to be a real decrease unrelated to reviewer subjectiveness. Some Action is needed to determine the cause of this decrease. One item that should be reviewed is average class GPA.

Curriculum Review Summary

The average score has remained low and is reflected in the non-subjective decreasing Senior Exit Exam scores from 2010 to 2015: 4.67, 4.71, 4.60, 3.78, 3.55, 3.67. It seems very unlikely this drop is the result of variations in student learning but rather because something has changed in the assessment methodology. Therefore, action is focused on assessment processes. Otherwise, a review of basic (Freshman & Sophomore)science and math instruction will be needed but only if other programs note the same decrease.

Code	Curriculum Action Title	Curriculum Action Brief Description
W	Low a) watch	If there is no improvement in a) assessments, a review of instructional methods is needed.

Previous Assessment Process Action Review Summary

Continue the Watch from 2013 per 2-year cohort system.

Assessment Process Review Summary

The results from MET 330 remain significantly lower than from other instruments. Conduct training and review on a) Metrics for faculty members.

Code	Assessment Process Action Title	Assessment Process Action Brief Description
A	Metrics Training and Review	Conduct a comparative review of a) outcome metrics and procedures.
A	Increase Senior Exam Prestige	Move the exit exam to earlier in the semester and have the Dept Head administer the testing.

C. Additional information

Appendix E contains the following additional assessment and evaluation documents for Outcome (a-k):

Items not present in Appendix E but available in hard copy form at the time of review are

- Archival Records
- Score Cards
- Outcome Summaries
- A panoply of Grand Summary renderings including
  - Graphical Summary of each outcome over time
  - Graphical Summary of all outcomes for each year
  - Two-year Averaged Grand Summary

All of this information is also continuously available to program faculty via the CIS web site.

D. Major curricular changes during 2010-15

Program faculty implemented a number of substantial changes into the curriculum during the last six years since the last ABET visit. These are cited below by outcome and by course.

The outcomes are listed here for convenient reference.

a) Apply knowledge of mathematics, science, and engineering
b) Design and conduct experiments, as well as to analyze and interpret data
c) 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) Function on multidisciplinary teams
e) Identify, formulate, and solve engineering problems
f) Understand professional and ethical responsibility
g) Communicate effectively
h) Know the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) Recognize the need for life-long learning
j) Know of contemporary issues
k) Use the techniques, skills, and modern engineering tools necessary for engineering practice.

<u>*Outcomes*</u>

(b)

New design of experiments exercises were introduced in MET 310L beginning in 2012.

(c)

Substantial changes were made to the MET 351/352 and MET 464/465 design sequence in 2012 with more emphasis on material and process selection. In 2013, more open-ended material selection problems were introduced into MET 332 course. **(c)**

(g)

Both junior and senior faculty made presentations in the design class (Met 351/464) to students attended so the department can form cohesive standards. All faculty members attend their colleagues presentations, and the overall effort led by Dr. Crawford.

(h)

The Global Societal Instructional Module was relocated in the curriculum to the combined Junior-Senior Design Sequence (MET 351/352/464/465).

<u>*Courses*</u>

MET 110 Introduction to Metallurgical Engineering

Beginning in fall of 2014, Dr. West made the following changes to the MET 110 course content.

1) Introduction of lab specific modules where students were expected to analyze data using software (excel). These changes address analyzing and interpreting data **(b),** ability to use tools **(k).**
2) Introduction of a new capstone project on “forensics of artifacts.” In this project, several reputed metallurgical artifacts and materials were gathered from a variety of sources (e.g. reputable galleries, ebay, internet). Student teams then conducted a metallurgical investigation to determine the authenticity of the artifacts. The investigation involved designing a plan using available departmental equipment and extensive use of lab characterization equipment used in metallurgical engineering. The investigation also included historical context of the time periods of metallurgy. These changes are connected to designing and conducting experiments **(b),** teamwork **(d)**, and modern engineering tools **(k)**.

MET 220L Mineral Processing and Resource Recovery

In the spring semester 2014 Dr. Kellar made substantial changes to the MET 220L course content. Specifically, the scientific and engineering content surrounding individual unit operations remained, but roughly 50 percent of the class was devoted to use of the unit operations on a team-based “real world” mineral separation problem. These changes were made to better engage the students in the laboratory with the goals of improving teaming **(d)**, communications **(g)**, analyze data **(a)** and to better solve engineering problems **(e)**. For example in 2016 the student teams were separate garnet from spent water jet cutting residue. Some background is warranted here. The water jet in question takes dry garnet (Barton minerals) and injects it with water under high pressure to cut the material in question. The spent water/garnet/fines slurry drops into a collection bed beneath the cut object. The slurry is typically removed and land filled. The manufacturer of the water jet cutter, OMAX, had an interest in recovering and reusing the garnet that still meets the original spec. We use the 80 HPA grade for the waterjet cutter located in the foundry. The MET 220 students found that approximately 30 percent of the garnet falls out of specification during water jet cutting, so the challenge was how to recover the garnet that can be dried and reused. The material from the cutting piece is typically very fine and would report with the smaller, out of specification garnet. The MET 220 project was deliberately left open ended and the students tried sieving, tabling, and magnetic and flotation to separate the materials. The most valuable results were found by dry screening. During this process the student teams had a Q & A session with an OMAX engineer, and gave both final oral and written reports. The final written report was shared with OMAX. http://www.barton.com/wp-content/uploads/2012/03/HPA_PSD_Graph.pdf

MET 231 Properties of Materials Laboratory

Dr. West and Dr. Jasthi developed two new course modules in the last reporting period. In 2013, they developed a lab critique module where students provide feedback to other students on a written laboratory report. In 2014, they developed a new laboratory assignment on mechanical properties of polymers. This was developed in conjunction with mechanical engineering faculty to introduce students to time dependent deformation principles. In 2015, they introduced a new seminar and workshop on technical report writing. In this workshop, faculty worked directly with student teams to re-write one of their early labs. The changes address engineering principles **(a)**, conducting experiments **(b)**, written communication **(g)**, and ability to use engineering tools **(k)**.

MET 310 Aqueous Extraction, Concentration and Recycling (2010, 2012, 2014)

The primary changes in MET 310 related to ABET curriculum outcomes have occurred to address **outcomes e, f, h and k**. With respect to **outcome (e) and (k),** homework problems specifically focused on formulating and solving engineering problems and using excel add-ins, like solver, to obtain answers for the engineering problems were added in 2014 and continued in 2016. An ethics-related writing component was added in 2014 and continued in 2016 **(outcome (f)).** In addition, global and societal context **(outcome (h))** was more directly included in a writing assignment beginning in 2014 and continuing in 2016.

MET 310L Aqueous Extraction, Concentration and Recycling Lab (2010, 2012)

Beginning in 2010 and continuing in 2012, Design of Experiments (DOE) components were added to MET 310L. These included multiple lectures on statistics and how they relate to DOE, lectures on using statistical software to perform DOE, and guiding the student groups through designing and performing a 2^2 full factorial experiment related to leaching of minerals. These changes relate to **outcome (b).** In the spring of 2014, Dr. Safarzadeh applied some modifications to the MET 310L course content. These modifications include the introduction of experimental design approach for systematic implementation of the experiments to improve **(b)**, and addition of three new experiments which would impact the students' skills in data analysis **(a)** and to better solve engineering problems (**outcome e**). In spring of 2015, professional and ethical responsibilities **(f)** were emphasized through lectures highlighting the importance of proper literature citations and cases of plagiarism.

MET 320 Metallurgical Thermodynamics

In the fall of 2015, Dr. Safarzadeh offered additional problem-solving sessions (in addition to the regular class meetings) to improve students' capabilities to apply their knowledge to solve engineering problems **(a)**.

MET 321 High Temperature Extraction, Concentration, and Recycling

In the spring of 2015, Dr. Safarzadeh offered two additional homework to emphasize the contemporary issues **(j)** and also the global societal context **(h)** in the context of high temperature processing (pyrometallurgy) of metals. In these homework, the students were assigned two papers to read and submit a summary of the global issues associated with smelting operations.

MET 332 Thermomechanical Processing

In 2011, Dr. West introduced two new in-class team problem solving exercises - one on hardenability of steels and the other on identification of an unknown aluminum alloy using heat treating. In 2013, Dr. West introduced several open-ended alloy selection take-home problems. The changes are linked to applying knowledge of engineering **(a)**, ability to solve engineering problems **(e)**, and teaming **(d)**.

MET 351/352/464/465 Metallurgical Engineering Design

<u>Broadened outcomes **(c)** and **(h)**</u> – All design reports were broadened to include formal sections on outcomes (c) and (h). Additionally, faculty members begin making presentations on 1) economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability constraints and 2) global, economic, environmental, and societal issues .

<u>Design Student Evaluations</u> - Implementation of self-evaluations, peer-evaluations, and faculty evaluations of individual student design performance in the areas of quality, timeliness, teamwork, and overall contribution. The primary reasons for implementing this evaluation program were to (1) encourage strong team performance and contribution from all members, (2) provide a mechanism for evaluating individual student performance in the design course. **(d)**

<u>Group Evaluations</u> - Group evaluations were developed as anonymous surveys (grouped by design team) where students reflect on their overall group performance, team effectiveness, project suitability, and, more generally, about the design course itself. **(d)**

<u>Industry inspired design projects</u> - In the Fall of 2013, a new initiative was started to develop industry inspired design projects. In the first year, five industry inspired design projects were developed with five different industry partners. In subsequent

years (2014 and 2015), seven industry inspired design projects were conducted each year. In each case, an industry lead and Met faculty member mutually identify ideal design project areas. Industry leads then actively participate as design advisors through weekly design meetings with the student design team. In many cases the industry partners have invited students for onsite visits of their facility. The overall objectives of this initiative were to engage students in practical industry design problems and to provide a mechanism for strengthening ties with relevant industry partners. To date the program has been an extreme success and will be continued in the future. **(c), (h), (e)**

Round-robin faculty evaluations - During this evaluation period we have modified the manner in which design reports and student oral presentations are evaluated. In this regard, semester design reports are now evaluated by a minimum of three faculty members and all comments are collected and returned to the student team. Furthermore, group oral reports (three per semester) are now evaluated by all faculty members and feedback is collected and returned to the student teams. This form of immediate and broad review has proved beneficial in helping students avoid pitfalls in the design process while also providing significant improvement in technical communication skills. **(g)**

Individual Technical Assignments – During this evaluation period a each student is required to complete an individual technical assignment which is directly supportive of their design project. This activity was initiated to (1) ensure application of technical skills developed through the MET undergraduate curriculum in the design process, and (2) to encourage full group participation in the design project (preventing so-called “social loafing”). **(a), (e), (k)**

Project Management Design Content **–** During this evaluation period, program faculty have made a concerted effort to increase student exposure to project management based content through the introduction of both formal lectures and practical training exercises into the design sequence. **(g), (g)**

MET 330/330L

Primary changes involve increased emphasis on state-of-the-art materials characterization tools and techniques. **(k)** Introduction of new laboratory exercises including a new lab focused on teaching the basics of dislocation properties using the “Bubble Raft” model. **(a), (b)**

MET 422 Transport Phenomena

In fall of 2014, Dr. Safarzadeh emphasized the application of students’ knowledge in transport phenomena in solving metallurgical engineering problems **(a)** by assigning homework problems that were directly linked to the real-world metallurgical problems.

MET 426 Steelmaking

Dr. Jasthi added the topics on “Early history of Iron and Steel Making” to bring a historical perspective to the students. He also demonstrated several steel making process simulations on “Steel University”. These interactive simulations have been designed as an educational and training tool for students for better understanding of steelmaking operations. These changes are linked to the selection of materials and design of materials for a specific production processes (**c)**.

MET 430/430L Welding Metallurgy and Engineering

Dr. Jasthi developed additional lab modules on laser welding, cold spray and corrosion testing of weld joints. The changes address selection of materials **(c)**, conducting experiments **(b)**, and ability to use engineering tools **(k)**. Dr. Jasthi also added several new sections to the course curriculum related to welding issues and corrosion in weldments. These topics are connected to the application of knowledge of science and engineering **(a)** and with the materials selection **(c)**

MET 440/440L Mechanical Metallurgy and Mechanical Metallurgy Laboratory

Introduction of new laboratory exercises including laboratories on fracture toughness testing, fatigue testing, and nanoindentation. **(b), (k)**

MET 445 Oxidation and Corrosion of Metals

Dr. Jasthi developed few lab modules on electrochemical corrosion testing during the last reporting period. With this introduction of these new lab modules, the students were able to get hands-on experience and were able to conduct experiments, analyze and interpret the data (**b**).

MET 450 Forensic Engineering

Course module on failure analysis of microelectronics was added. **(e)**