PURDUE SCHOOL OF ENGINEERING AND TECHNOLOGY 2016-2017 ACADEMIC YEAR ASSESSMENT REPORT

Prepared by the School's Assessment Committee and Karen Alfrey, Chair
September 8, 2017

Introduction

The Purdue School of Engineering and Technology, IUPUI (E&T) continues its tradition of reporting its outcomes assessment activities by department or (where appropriate) by academic program. The assessment activities of most programs in the school are guided by the discipline-specific accreditation requirements of ABET, Inc. (http://abet.org/, formerly the Accreditation Board for Engineering and Technology), which accredits our engineering, technology, and computing programs; of the National Association of Schools of Music (NASM, http://nasm.arts-accredit.org/), through which the department of Music and Arts Technology is accredited; and of the Council for Interior Design Technology (CIDA, http://www.accredit-id.org/), the accrediting body for our Interior Design Technology program. The Organizational Leadership and Supervision (OLS) program, which is not accredited at the program level, uses the campus's Principles of Undergraduate Learning (PULs) as their framework for program assessment. Technical Communications (TCM) offers a certificate program and a recently-established Bachelor's degree in Technical Communication, as well as providing supporting coursework (and assessment data on student learning outcomes in those courses) for many of the programs in the school.

School Assessment Processes

The program outcomes defined by ABET, NASM, and CIDA to describe the knowledge, skills, and habits of mind expected of successful graduates of these programs cover the same broad areas as IUPUI's Principles of Undergraduate Learning, but with more specificity appropriate to the needs of each discipline. (ABET outcomes for engineering programs, for example, include several outcomes that could be considered specific examples of Quantitative Skills, one of the PULs.) Thus, by focusing on attainment of discipline-specific outcomes, programs are assured of meeting the more broadly-defined PULs.

Student Learning Outcomes for each undergraduate program are published in the Bulletin: http://bulletins.iu.edu/iupui/2017-2018/schools/purdue-engineer-tech/undergraduate/student_learning_outcomes/index.shtml. For engineering programs, ABET defines eleven core outcomes (commonly designated as "a through k" in keeping with ABET terminology):

> Upon completion of this program, students will be able to demonstrate:
> 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 multidisciplinary 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, 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.

For baccalaureate degree programs in engineering technology, the eleven core “a through k” ABET outcomes are:

Upon completion of this program, students will be able to demonstrate:
a. an ability to select and apply the knowledge, techniques, skills and modern tools of their disciplines to broadly-defined engineering technology activities;
b. an ability to select and apply a knowledge of mathematics, science, engineering and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;
c. an ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;
d. an ability to design systems, components or processes for broadly-defined engineering technology problems appropriate to program educational objectives;
e. an ability to function effectively as a member or leader on a technical team;
f. an ability to identify, analyze and solve broadly-defined engineering technology problems;
g. an ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;
h. an understanding of the need for and an ability to engage in self-directed continuing professional development;
i. an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
j. a knowledge of the impact of engineering technology solutions in a societal and global context; and
k. a commitment to quality, timeliness, and continuous improvement.

Each undergraduate course taught in the school has identified one or more emphasized PULs, as well as any discipline-specific outcomes emphasized in the course. Based on these defined areas of emphasis, specific courses may be targeted for assessment of a given outcome. The bulk of program assessment is administered and performed at the department level, with the school assessment committee providing a mechanism for sharing resources and best practices, as well as disseminating information and guidance on new campus-level assessment processes. Due to the needs of program accreditation, most assessment data is framed in the language of discipline-specific outcomes; however, due to the significant overlap between these disciplinary outcomes and the broader language of the PULs, programs that successfully meet their disciplinary outcomes simultaneously satisfy the PULs; and mappings between discipline-specific outcomes and the PULs have been established for each program. An example of such a mapping is shown in the table on the next page. In the 2018-2019 academic year these mappings will see significant revision as IUPUI moves from PULs to new PLUS outcomes; and ABET has announced revisions to its Student Learning Outcomes that will take effect beginning in the 2019-2020 assessment cycle.

Prompted by the establishment of Principles of Graduate Learning at IUPUI, graduate programs in the School of Engineering and Technology have likewise established student learning outcomes, published in the Bulletin: http://bulletins.iu.edu/iupui/2017-2018/schools/purdue-enginer-tech/graduate/student_learning_outcomes/index.shtml Due to the highly specialized, integrative nature of graduate programs, assessment of these outcomes focuses primarily on the thesis (or final project) rather than on individual courses.

ABET/EAC Criteria #3 2011-12 Evaluation Criteria **Engineering programs must demonstrate that their students attain:**	**INDIANA UNIVERSITY-PURDUE UNIVERSITY INDIANAPOLIS PRINCIPLES OF UNDERGRADUATE LEARNING**							
	PUL 1 Core Communication and Quantitative Skills			**PUL 2 Critical Thinking**	**PUL 3 Integration and Application of Knowledge**	**PUL 4 Intellectual Depth, Breadth, and Adaptiveness**	**PUL 5 Understanding Society and Culture**	**PUL 6 Values and Ethics**
	A	**B**	**C**					
(a) an ability to apply knowledge of mathematics, science, and engineering		X		X	X	X		
(b) an ability to design and conduct experiments, and analyze and interpret data		X		X	X	X		
(c) an ability to design a system, component, or process to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability				X	X	X		
(d) an ability to function on multidisciplinary teams	X					X	X	
(e) an ability to identify, formulate, and solve engineering problems		X		X	X	X		
(f) and understanding of professional and ethical responsibility				X	X	X	X	X
(g) an ability to communicate effectively	X						X	
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context					X	X	X	X
(i) a recognition of the need for, and an ability to engage in life-long learning			X	X			X	X
(j) a knowledge of contemporary issues				X		X	X	X
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice			X		X	X		

School Assessment Milestones

The Mechanical Engineering and Energy Engineering programs submitted an interim assessment report to ABET to address questions about advising processes and procedures for systematically reviewing and updating Program Educational Objectives, the broad statements about what graduates are expected to be prepared to accomplish professionally upon completion of the degree program. These reports were submitted over the summer and await review by ABET.

Due to changes in curriculum that strengthen the Construction Management aspects of the program and decrease the emphasis on engineering technology, and at the recommendation of its Industrial Advisory Board, the Construction Engineering Management Technology program will be seeking accreditation by the American Council for Construction Education (ACCE), which is expected to replace its ABET accreditation on the next ABET cycle. The program has drafted a self-study for ACCE and anticipates a Spring 2019 visit. Consistent with the shift of program focus, the program has submitted a request for a change of program name, from Construction Engineering Management Technology to Construction Management. This change has been approved by the IUPUI Undergraduate Affairs Committee and awaits final approval from the Purdue Academic Affairs Committee.

The other ABET-accredited Technology programs (Electrical and Computer Engineering Technology, Mechanical Engineering Technology, Healthcare Engineering Technology Management) are currently collecting data and drafting self-studies for submission in Summer 2019, in preparation for their next ABET visit in Fall 2019.

The E&T 2017-2018 Assessment Committee

This year the E&T Assessment Committee was chaired by Karen Alfrey, Director of the Undergraduate Program in Biomedical Engineering. The members of the 2017-2018 committee were the following:

Karen Alfrey, Biomedical Engineering
Mark Atkins, Ivy Tech
Mary Baechle, Technical Communications
Dan Baldwin, Computer Graphics Technology
J. Bradon Barnes, Ivy Tech
Andrew Borme, Motorsports Engineering
Elaine Cooney, Engineering Technology
Robin Cox, Music and Arts Technology
Eugenia Fernandez, Computer Information and Graphics Technology
Elizabeth Freije, Electrical and Computer Engineering Technology
Michael Hall, Ivy Tech
Maymanat Jafari, E&T Librarian
Alan Jones, Mechanical Engineering
Michele Luzetski, New Student Academic Advising Center
Meganne Masko, Music and Arts Technology
Emily McLaughlin, Interior Design Technology
David Russomanno, Dean
Seemein Shayesteh, Electrical and Computer Engineering
Elizabeth Wager, Organizational Leadership and Supervision
Jennifer Williams, Career Services
Wanda Worley, Associate Dean for Undergraduate Programs
Paul Yearling, Mechanical Engineering Technology

Departmental and Program Annual Reports for 2017-2018

The 2017-2018 departmental and program assessment reports included in this school report represent the collected works of the following two programs, both of which had significant assessment-related activities this year:

- Construction Engineering Management Technology (CEMT)
- Biomedical Engineering (BME)

The table below outlines reporting for the school over the last several years. Previous years' reports are available at https://planning.iupui.edu/assessment/prac-files/school-reports/prac-school-reports.html.

Programs		2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
BME		x	x	x	x	x	x
EE/CE			x			x	
ME/EEN			x	x			
MSTE			x				
CIT			x	x			
CGT			x	x			
INTR		x	x			x	
TCM		x			x		
OLS		x			x		
ECET		x	x			x	
MET		x	x				
HETM		x	x			x	
CEMT		x	x				x
MAT					x		
NSAAC				x			

Construction Engineering Management Technology
2017-18 Assessment Report

The Construction Engineering Management Technology (CEMT) program is preparing to seek a new program accreditation from the American Council for Construction Education (ACCE) in place of its existing ABET accreditation. This change comes in part from recommendations from the program's Industrial Advisory Board, and acknowledges the fact that over time the program curriculum has moved away from its roots in Civil Engineering Technology and toward a stronger focus in construction management. Along with the change in accreditation, the program is requesting a name change for the major from Construction Engineering Management Technology to Construction Management. This request has been approved by the IUPUI Undergraduate Affairs Committee and now awaits review by the Purdue University Academic Affairs Committee.

The CEMT program has a long history of outcomes assessment to meet ABET accreditation requirements. Recent focus has been realignment of outcomes and processes to meet ACCE requirements. This report summarizes these new processes and assessment results, and is drawn from the self-study prepared in advance of an anticipated Spring 2019 ACCE accreditation visit.

ACCE defines 20 Student Learning Outcomes for the construction discipline:

1. Create written communications appropriate to the construction discipline.
2. Create oral presentations appropriate to the construction discipline.
3. Create a construction project safety plan.
4. Create construction project cost estimates.
5. Create construction project schedules.
6. Analyze professional decisions based on ethical principles.
7. Analyze construction documents for planning and management of construction processes.
8. Analyze methods, materials, and equipment used to construct projects.
9. Apply construction management skills as a member of a multi-disciplinary team.
10. Apply electronic-based technology to manage the construction process.
11. Apply basic surveying techniques for construction layout and control.
12. Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
13. Understand construction risk management.
14. Understand construction accounting and cost control.
15. Understand construction quality assurance and control.
16. Understand construction project and control processes.
17. Understand the legal implications of contract, common, and regulatory law to manage a construction project.
18. Understand the basic principles of sustainable construction.
19. Understand the basic principles of structural behavior.
20. Understand the basic principles of mechanical, electrical, and piping systems.

CEMT Courses	ACCE Student Learning Outcomes																			
E=Assess/Evaluate	Create					Analyze			Apply			Understand								
S=Supporting Course	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CEMT 10400									S	S	S									
CEMT 10500						E	S			E								E		
CEMT 11000														S						
CEMT 12000								S		S					S					
CEMT 16000																			S	
CEMT 21500																			S	E
CEMT 26000								S											S	
CEMT 26700								S							S				S	
CEMT 27500			S					S									S		S	
CEMT 28000				S			S		S											
CEMT 31200									S	S	E									
CEMT 33000								E												
CEMT 34100					S					S						E				
CEMT 34200				E				S		S		S		E				S		
CEMT 34700						S	E			S		E					E			
CEMT 35000					E							S		S	E	S	E	E		
CEMT 39000	E																			
CEMT 43000	S							S												
CEMT 44700	S	E	S	S	S		S		E	S		S	E		S					
CEMT 45200	S									S										S
CEMT 45500		S	E			S							S							
CEMT 48400			S					S											E	
CEMT 48600								S											S	
CEMT 49400	S									S				S						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Table 1: ACCE Student Learning Outcomes in CEMT Courses

Table 1 shows the courses in the curriculum that support development of these outcomes (S) and those that are targeted for direct assessment and evaluation of each outcome (E). Direct assessment measures include one or more assignments for each outcome, sometimes supplemented by relevant quiz or exam questions. The program also indirectly assesses these outcomes as part of an ACCE Student Learning Outcomes Survey given to graduating seniors.

Table 2 summarizes the results from each direct assessment measure for data collected between Spring 2017 and Spring 2018, and Table 3 shows the averaged results for the Student Learning Outcomes Survey. For the purposes of program-level assessment, an outcome is considered to be satisfactorily met if students score at a level of at least 75% on each measure used to assess that outcome. Direct measures that meet this target are indicated with a green Y, and those that do not are indicated with a yellow or red N (yellow if the results missed the target by fewer than 5 points, red if they missed the target by a larger margin).

Outcome	Measure Used	Data Collected	Avg Score	75% Target Met?
1	Work Report	SP, SU, FA 17	84.2%	Y
2	Oral Presentation	SP 18	93.5%	Y
3	Safety Plan	FA 17	97.5%	Y
4	Lab Assignments	SP 18	85.7%	Y
	Term Project	SP 18	80.8%	Y

5	Project Breakdown	SP 18	92.5%	Y
	Cost Analysis	SP 18	95.0%	Y
	MS Project use	SP 18	74.0%	N
	Project Update	SP 18	58.0%	N
	Project Final Update	SP 18	79.5%	Y
	Overall Project	SP 18	73.0%	N
6	Ethics Assignment	SP 18	80.0%	Y
7	Project Executive Summary	FA 17	78.9%	Y
	Total Project Score	FA 17	83.7%	Y
	Specifications Assignment	FA 17	87.7%	Y
8	Analysis Assignments	SP 17	80.6%	Y
	Quiz	SP 17	78.5%	Y
	Exams	SP 17	77.8%	Y
9	Teamwork Assignment	SP 18	88.0%	Y
10	Revit Assignment	FA 17	85.5%	Y
	Building Info Management Exam Questions	FA 17	71.0%	N
11	Final Exam (Written and Practicum)	FA 17	82.0%	Y
12	Exam Questions	FA 17	58.3%	N
	General Conditions research assignment	FA 17	97.9%	Y
	Contract Manager In-Lab Exercise	FA 17	88.9%	Y
13	Risk Assessment Assignment	SP 18	78.2%	Y
14	Labor Rate Calculation assignment	SP 18	76.7%	Y
	Lab Assignment	SP 18	85.7%	Y
	Exam Questions	SP 18	73.7%	N
15	Homework assignment	FA 17	92.5%	Y
	Quiz	FA 17	72.0%	N
16	Scheduling assignment	FA 17	82.0%	Y
	Earned Value manual calculation assignment	FA 17	87.0%	Y
	Earned Value MS Project assignment	FA 17	92.0%	Y
	Exam	FA 17	78.0%	Y
17	CEMT 35000 Homework Assignments	FA 17	92.6%	Y
	CEMT 35000 Quizzes	FA 17	73.3%	N
	CEMT 34700 MidtermExam Questions	SP 18	85.5%	Y
	CEMT 34700 Final Exam Questions	SP 18	72.3%	N
18	CEMT 10500 Exam Questions	FA 17	65.5%	N
	CEMT 35000 Homework Assignments	FA 17	92.5%	Y
	CEMT 35000 Quizzes	FA 17	77.5%	Y
19	Calculating forces under loading	SP 17	90.6%	Y
20	HVAC system configuration assignment	SP 17	84.0%	Y

Table 2: Summary of direct assessment results for each ACCE learning outcome. An outcome is considered satisfactorily met at the program level if students score at least a 75% average on each assessment measure for that outcome.

The Student Learning Outcomes Survey is administered to graduating seniors each semester as an indirect assessment of their learning. Students are asked to rate how well the program helped them achieve each ACCE outcome on a 5-point scale (5 = excellent, 4 = good, 3 = satisfactory, 2 = fair, 1= poor.) The target score for each survey item is 3.5 (between satisfactory and good); data collected between Spring 2017 and Spring 2018 show that the program is exceeding this target on every outcome (Table 3).

Outcome	1	2	3	4	5	6	7	8	9	10
Score	4.6	4.7	4.4	4.5	4.4	4.7	4.9	4.4	4.7	4.9
Outcome	11	12	13	14	15	16	17	18	19	20
Score	4.2	4.8	4.4	4.8	4.5	4.6	4.3	4.2	4.5	4.3

Table 3: Summary of results from Student Learning Outcomes Survey. Items are scored on a 5-point scale.

Proposed Improvements Based on Evaluation Results

In CEMT 39000, a required construction internship experience, students submit a Work Report used to evaluate Outcome 1 (Written Communication). In addition, the program requires students to use NoteVault, a software communication program for sending notes and pictures between a job site and home office, to send course instructors progress reports at least once per week. The goal is to get students familiar with using this tool that may increase their marketability in the construction industry. However, submission of these reports is not currently a requirement of the Grade Performance Criteria for the course. Beginning Fall 2018, this requirement will be added to the grading criteria and weekly reports will be included as a component of the Work Report for future assessment.

In CEMT 45500 Construction Safety and Inspections, students submit a Safety Plan used to evaluate Outcome 3 (Create a Construction Project Safety Plan). Course evaluators noted that the material covered in this course and used for the Safety Plan closely aligns with the requirements necessary for OSHA 10 certification; it is proposed that future offerings of the course integrate explicit OSHA 10 training to prepare students for this certification. Students also requested this change in their comments on end-of-semester course evaluations.

CEMT 35000 Construction Project Cost and Production Control uses a term project with several individual components to evaluate Outcome 5 (Create Construction Project Schedules). Scores were particularly low on the portions of the project requiring the use of MS Project. The instructor notes that because the course does not have a built-in lab component, students needed to access this software using either computer labs on campus or IUanyare. During the first part of the semester, students reported difficulty accessing computer labs due to the many other classes scheduled into those rooms, and had trouble printing and saving the necessary files when using the IUanyware interface. Toward the end of the semester, the instructor received authorization from Microsoft for students to download MS Project onto their personal computers, for free use until the end of the semester. With this improved access, final updates showed substantial improvement over prior update reports; and the instructor has authorization from Microsoft to allow students in future semesters to make use of this free download option.

CEMT 10500 Introduction to Construction Technology uses a project in Revit, a technology tool for construction design and analysis, along with several exam questions on Building Information Management (BIM) software tools and processes to evaluate Outcome 10 (Apply electronic-based technology to manage the construction process). While they scored well overall on a technology-based project, scores on BIM exam questions fell short of the 75% target. In future semesters, additional class time will be spent addressing BIM and its capabilities, which should help improve student familiarity both in this course and in subsequent courses for which it is a prerequisite.

CEMT 34700 Construction Contract Administration & Specification uses exam questions and laboratory exercises to assess Outcome 12 (Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process). Students scored well on laboratory activities, but fell well short of the 75% target on exam questions related to project delivery methods. To address this shortfall, an in-class activity will be created that requires students to discern the differences in delivery systems. It will present varying project scenarios requiring the student to determine which delivery system would best address the unique characteristics of each project. In addition, more discussion of advantages and disadvantages of each delivery system will be added to the course.

CEMT 34200 Construction Cost and Bidding uses a homework and lab assignment as well as midterm exam questions to assess Outcome 14 (Understand construction accounting and cost control). While students performed well overall on a lab assignment on multiple crew rate calculations, they performed only slightly above the target of 75% on a labor rate calculation homework, and just below this target rate on several midterm exam questions related to labor rate, crew rate, and depreciation and interest. Based on these assessments, students particularly seem to struggle with labor rate calculations, so in future semesters additional instruction will be added specific to labor rate calculations and labor burden.

CEMT 34700 Construction Contract Administration and Specifications uses a midterm and a final exam to assess Outcome 17 (Understand the legal implications of contract, common, and regulatory law to manage a construction project). While students scored well overall on the midterm exam, their overall performance on the final exam did not meet the 75% target. Further analysis revealed that students scored particularly poorly on questions related to construction RFI (Request for Information), construction change directives, and submittal process responsibilities. To address these shortcomings, future offerings of the course will incorporate the following:

- An in-class RFI exercise that reinforces the nature of the RFI process
- Lecture material that clarifies the distinctions between different change mechanisms: change order, change directive, architect's supplemental instruction
- Lecture materials that clarify role responsibilities as legally assigned by the General Conditions of the Contract for Construction

Outcome 18 (Understand the basic principles of sustainable construction) is assessed in both CEMT 35000 and CEMT 10500. While students performed above the target level of 75% on assignments and quizzes in CEMT 35000, in CEMT 10500 they scored well below the target level on several exam questions related to sustainability. In his analysis, the instructor notes that the Fall 2017 semester was the first time a Sustainability unit was incorporated into CEMT 10500, and it fell in the final week of the semester. The material was presented through in-class lecture and activities only, with no related homework assignment to reinforce it. In future semesters the instructor will work to incorporate some of this material earlier in the semester with reinforcing homework assignments to give students deeper understanding and retention of Sustainability topics.

DEPARTMENT OF BIOMEDCIAL ENGINEERING 2017-18 ASSESSMENT REPORT NARRATIVE

August 2018

2017-18 Undergraduate Program Assessment Summary

- Per our assessment plan, BME faculty reviewed and finalized the 2017-18 assessment plan and performed data collection (Student Outcomes a-k). Data collected are being assessed.
- With the ABET Board approved EAC changes (as of October 2017), the Department began the process of remapping the existing Student Outcomes a-k to the newly approved ABET Student Outcomes 1-7. Student Outcomes a-k were used in data collection and analysis for our internal 2017-18 cycle, but comments and recommendations going forward will encompass the new Student Outcomes 1-7, refined definitions, and pertinent *Criterion 5: Curriculum* changes.
- The Biomedical Engineering Department is preparing for the IUPUI internal processes of implementing updates to the BS BME undergraduate plan of study.

The undergraduate Biomedical Engineering program participated in an ABET accreditation visit in Fall 2016. The Executive Board convened in 2017 to review program visits from the previous year and to make final accreditation decisions. As of Fall 2017, the undergraduate BME program at IUPUI was officially re-accredited for the full six years until the next general review. The BME Department follows an assessment schedule that allows for two 3-year cycles of data collection, analysis, and program improvements within each 6-year ABET cycle as delineated in Table 1. The major assessment activities of the 2017-18 academic year focused on the review of assessment plan and data collection. Learning outcomes assessment is ongoing.

Table 1: BME Program Assessment Schedule

Task	**Frequency**	**Scheduled**	
Review of assessment plan	Every 3 years	Summer 2017	Summer 2020
Learning outcomes data collection		2017-18	2020-21
Learning outcomes assessment		Summer 2018	Summer 2021
Alumni Survey/Focus Group/Industrial Advisory Board meeting		Fall 2018	Fall 2021
Student Satisfaction Surveys		Spring 2019	Spring 2022
Self-Study	Every 6 years	n/a	2021-22
ABET Visit		n/a	Fall 2022

Review of assessment plan

In summer of 2017, BME faculty began reviewing and updating learning outcomes present on our assessment plan. Individual meetings with primary BME faculty teaching within the undergraduate curriculum and assessment coordinators reviewed the assessment plan for data collection. The review prepared us for data collection during the 2017-18 academic year. Data collected targeted ABET Student

Outcomes a-k, however, faculty discussions involving the soon-to-be-approved ABET changes (Student Outcomes 1-7) has been ongoing. The assessment plan used to collect data identified a map of learning outcomes targeted for each assessment in each required BME course (Table 2), specific Performance Indicators defined for each assessed outcome (e.g. "Students will successfully complete a laboratory assignment with a pre-lab component, data collection component, and analysis component" as an indicator of Outcome B), and a Target for Performance (e.g."70% of students will earn grades of 70% or higher in the assessed lab assignment") for each Performance Indicator listed. Appendix A shows the 2017-18 assessment plan with learning outcomes, performance indicators and targets for performance.

ABET Approved Changes for EAC (October 2017)

As of October 2017, ABET approved changes, revisions, and proposed program criteria to be implemented beginning in the 2019-2020 Cycle. Approved changes for the EAC (Engineering Accreditation Commission) include:

1. *Introduction and definitions that apply to all parts of criteria:* ABET updated the definitions of Basic Science, College-level Mathematics, Engineering Design, and Engineering Science and introduced definitions for Complex Engineering Problems and Team.
2. *Criteria 3, Student Outcomes:* Updated Student Outcomes 1-7
3. *Criteria 5, Curriculum:* Language changes emphasized a program's ability to deliver adequate content and prepare students to enter the practice of engineering, defined minimum credit hours earned for college-level mathematics/basic sciences (30 semester credit hours or equivalent) and engineering topics appropriate to program (45 semester credit hours or equivalent), linked technical content langue to program educational objectives, and described requirements of a culminating major engineering design experience (incorporate engineering standards and constraint and is based on knowledge/skills from earlier course work).

The preliminary mapping between ABET Outcomes a-k and the new ABET Outcomes 1-7 has been started (Table 2). Outcomes targeted for assessment in BME required courses in our plan of study are shown. Our program aims to assess each outcome if possible at the beginning, middle, and end of the plan of study. Based on the October 2017 approved ABET changes, our Department continues to review and adapt our assessment plan, keeping new definitions in mind particularly as some new Student Outcomes (1-7) have collapsed the old Student Outcomes (a-k).

ABET Outcomes 1-7

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Table 2: Re-mapping of BS BME Curriculum to New ABET Student Outcomes 1-7

			1		2	3	4			5	6	7
	Course Title	Course	a	e	c	g	f	h	j	d	b	i
Year 1	Engr Seminar	ENGR 195					X					X
	Engr Prob Solving	ENGR 196						X				X (k)
Year 2	Biomeasurements	BME 222				X				X	X (k)	X
	Intro Biomechanics	BME 241	X	X							X	
Year 3	Biosignals/Systems	BME 331		X	X							
	Biomedical Computing	BME 334	X (k)			X					X (k)	
	Implantable Materials	BME 381	X									
	Probs in Implant Mat	BME 383			X							
	Prob/Stat for BME	BME 322									X	
	Tissue Behavior/Prop	BME 352					X		X			
	Probs in Tissue Beh/Prop	BME 354								X		
Year 4	Quantitative Physiology	BME 411				X						
	Biofluid Mechanics	BME 442		X								
	Transport Proc in BME	BME 461	X									
	BME Senior Design I/II	BME 491/492			X		X	X	X	X	X (k)	
	BME Seminar	BME 402										X
	Comm in Engr Practice	TCM 360				X		X				

Major Findings from Data Collection

Several important findings emerged from the analysis of data performed on data collected during the 2017-18 academic year. Data indicate that we are successfully meeting the majority of performance targets for our outlined performance indicators. Outcomes D, F, G, H, I, and J all show that our students are performing at or above the defined targets. The following discusses Performance Indicators not meeting the defined target as outlined in the 2017-18 assessment plan.

Outcome A: With regards to Outcome A, we found a higher percentage of students in Introduction to Biomechanics (BME 24100) were achieving the performance target (63.2% of students scored at least 70% in 2017 vs. 35.7% in 2014) despite a similar number of students in both data collection years earning at least a B- (or 60%) on the assessed problem. As BME 24100 is likely the first course our students encounter in our program, many do not yet understand the instructor/program expectations. This still seems to be the case for a subset of the students enrolled in this course. In talking with the instructor, he would like to reintroduce quizzes into the lecture portion of the class (instead of the lab) and evaluate student performance on this problem in a more striated fashion going forward to better understand where students are not understanding the material. The target for performance was adjusted from 70% of students will score at least 80% on assessed problem(s) (2014) to 70% of students will score at least a 70% on assessed problem(s) (2017) and will continue to be 70% as data collection continues.

Similarly, for BME 38100, students fell short on assessed exam problems; however, students are performing well on the quiz defined as a Performance Indicator. We are currently re-evaluating our stated Targets for Performance to determine whether they need to be adjusted, particularly for exam questions in BME 38100, to set more realistic goals of what a competent student in our program should be able to achieve.

Outcome B: Overall, the majority of the Performance Indicators show that our students are meeting targeted performance levels at various points throughout the curriculum. Specifically, performance on an exam problem in BME 32200 (Probability and Applications for BME) showed >25% increase in performance when compared to our last data collection (2015 vs. 2018). In 2018, a different BME faculty member taught the course and may have covered this material in more depth or differently to help raise student achievement in this area. Still, another exam problem in the same course showed consistency in students missing the targeted performance level (45% of students scored at least a 70% in 2018 vs. 50% in 2015). In consultation with the course instructor, it seems that the material assessed on this exam problem is delivered within the last two weeks of the course and is assessed on the cumulative final exam. It appears that students are not mastering this material as well as material introduced earlier in the semester. Going forward, the instructor will review the syllabus to see if this material can be introduced earlier or adapt how the final is graded (e.g. the question will be weighted heavier than previous material) to improve student performance.

Outcome E: Homework assessments demonstrate that students consistently perform at or above set target for performance levels; however, exam problems assessed show our students fall shy of our targets set in BME 24100 (Introduction to Biomechanics) and BME 44200 (Biofluid Mechanics). Again, in talking with the BME 24100 instructor, he would like to reintroduce quizzes into the lecture portion of the class (instead of the lab) and evaluate student performance on this problem in a more striated fashion going forward to better understand where misunderstanding occurs. With respect to BME 44200, students are performing well on homework problems, but fell just short on 2 of 3 assessed exam problems. We come much closer to meeting our goal when we use a cutoff of students earning a 60% on assessed exam problems, which was considered satisfactory in assessing student performance. As such, we are not particularly too concerned about student performance in biofluid mechanics.

Outcome K: At varied positions within the Plan of Study (ENGR 19600, BME 33400, BME 49100), student performance is consistently above the set target for performance. One dip in performance seen during the 2017 data collection cycle was seen on an exam problem in BME 33400 (29% of students scoring at least 70% in 2017 vs. 82.6% of students scoring at least 70% in 2014). One factor affecting student performance in this course was that BME 33400 was co-taught by two BME faculty (a visiting faculty member in the department). As such, not as much time was devoted to practicing methods for solving differential equations as the course implemented a new finite element project. In addition, students were assessed on the first exam in 2017 instead of the second exam as was the case in 2014. With further review of the exam problem, faculty are not specifically concerned as of this data collection cycle, as nearly 70% of students did score satisfactorily on the problem. The instructors of the course going forward can introduce practice problems sets where students continue refining their numerical methods for solving differential equations.

New Initiatives to Improve Student Learning

Faculty have also been engaged in external, curriculum-related activities to enhance understanding of syllabus design and writing student outcomes to learning contemporary methods used in industry when bringing a medical device to market.

- American Society for Engineering Education – Streamlined Course Design. Online program for planning and implementing improved courses. Four BME faculty participated in spring 2018 to improve BME 24100, BME 22200, BME 32200, and BME 49100.
- NSF-Cultivating Cultures of Ethical STEM Grant secured through IUPUI STEM Education Innovation & Research Institute – the project aims to increase faculty's ability to integrate reflection and community engagement in the BME curriculum. Five BME faculty are participating.
- BMES Coulter College Participant – training program to help students and faculty learn how to translate biomedical innovations. Four seniors and one faculty attended summer 2018.
- Curriculum Enhancement Grant (CEG) – provides faculty with support to implement projects designed to improve student learning. Two BME faculty secured the CEG and are developing hands-on design modules for 200- and 300-level BME courses.

Results of Improvement from 2015 Assessment Cycle

Our BME program has consistently incorporated new initiatives to improve student learning. Many recent initiatives and the evidences that precipitated implementation are highlighted in Table 3. The results of implementation show:

- Students are interested in biomaterials/tissue engineering upper-level courses. We will continue to monitor interest and see if any additional topics can be introduced.
- Implementing peer mentoring in BME 32200, BME 33100, and BME 22200 is showing positive effects on DFW rates.
- Faculty are currently working on implementing more design-related experiences earlier in the curriculum.
- BME curriculum changes are moving forward towards implementation.

Table 3: New Initiatives to Improve Student Learning in the BME Curriculum

<table>
<tr><th>Academic Year</th><th>New Initiative to Improve Learning</th><th>Evidence to Implement</th><th>Result of Implementing Initiative</th></tr>
<tr><td>2014-15</td><td>Added two new 400-level electives as options for Biomaterials/Tissue Engineering track students

Introduced ANSYS mechanical modeling module in BME 24100</td><td>Alumni survey</td><td>Since 2014, student enrollment in Tissue Engineering and Advanced Biomaterials has reached 22 and 21 students, respectively.<table><tr><th></th><th>2018</th><th>2017</th><th>2015</th><th>2014</th></tr><tr><td>Tissue Eng.</td><td>9</td><td>-</td><td>8</td><td>5</td></tr><tr><td>Adv. Biomat.</td><td>4</td><td>2</td><td>6</td><td>7</td></tr></table></td></tr>
<tr><td>2015-16</td><td>Peer Mentoring in BME 32200, BME 33100, and BME 22200</td><td>DFW rates, low exam scores

Faculty/instructor feedback of lack of student engagement or participation</td><td>DFW Rates for BME 32200, BME 33100, and BME 22200<table><tr><th></th><th>17-18</th><th>16-17</th><th>15-16</th><th>14-15</th></tr><tr><td>222</td><td>18%</td><td>33%</td><td>23%</td><td>38%</td></tr><tr><td>331</td><td>6%</td><td>8%</td><td>0%</td><td>9%</td></tr><tr><td>322</td><td>0%</td><td>0%</td><td>4%</td><td>8%</td></tr></table></td></tr>
<tr><td>2016-17</td><td>Emphasize iterative process in senior design.

Add design-related problems earlier into curriculum.

Look for new model of incorporating more formal instruction on lab report and scientific writing, both individual and group presentation.</td><td>Faculty panel review of student presentations and projects

Feedback from student course evaluations, advising meetings and surveys</td><td>Two BME faculty secured internal Curriculum Enhancement Grant funding to introduce design-related problems earlier in the BME curriculum.

Discussions with the technical communication department have started regarding changes to our technical communication requirement (TCM component in sophomore and junior year)</td></tr>
<tr><td>2017-18</td><td>As the department hits the 10-year mark, the BME Faculty took the 2017-18 academic year to review student performance, interviews, and more to recommend changes to the undergraduate BME curriculum.</td><td>Faculty panel review of student presentations and projects

Senior Exit Interviews

Performance Indicator data from Outcomes A, E

New ABET Outcomes 1-7 and stated definitions of team, engineering design.</td><td>BME curriculum changes:
- Add Biomaterials as required junior level course
- Spread technical communications over sophomore and junior year (paired with BME lab class)
- Introduce design in junior level course prior to senior design
- Remove life science laboratories as requirements and move pertinent content into BME labs</td></tr>
</table>

Graduate Program Assessment and Improvement

This year, the BME Graduate Committee has focused on updating and clarifying language for procedures within the graduate handbooks. Specifically, the Committee amended the following:

- Updated English requirement for international students
- Removed BME 50100/50200 course requirement, and replaced with advising consultation (all incoming Master's students will have their skills assessed during an initial advising meeting)
- Clarified procedures on counting BME 69600/BME 69700 towards student's plan of study, on submitting course petitions, and for filing a Plan of Study

APPENDIX A

BIOMEDICAL ENGINEERING STUDENT LEARNING OUTCOMES MAP WITH PERFORMANCE INDICATORS AND TARGETS FOR PERFORMANCE (used in 2017-18 data collection)

Outcome A: Students will demonstrate an ability to apply knowledge of mathematics, science, and engineering.

Performance Indicators	**Method(s) of Assessment**	**Where data are collected**	**Year(s)/Semester of Data Collection**	**Target for Performance**
Students will apply knowledge of mathematics, physics, and mechanics to solving a biomechanics problem.	Exam problems	BME 241	Every three years (next: fall 2017)	70% of students will score at least 80% on assessed problems
Students will analyze a scientific paper from the literature by identifying the hypothesis, proposing the next experiment needed to test the hypothesis, and discussing how the results might be applied in developing a new product or therapy	Quiz	BME 381	Every three years (next: fall 2017)	70% of students will score at least 80% on the assessed quiz
Students will apply mathematical analysis to problems related to implantable materials and biological response	Exam problems	BME 381	Every three years (next: fall 2017)	70% of students will score at least 80% on the assessed problems
Students will apply knowledge of mathematics, science, and engineering to solving problems related to diffusion and transport	Homework and exam problems	BME 461	Every three years (next: spring 2018)	70% of students will score at least 70% on assessed problems

Outcome B: Students will demonstrate an ability to design and conduct experiments, as well as to analyze and interpret data.

Performance Indicators	**Method(s) of Assessment**	**Where data are collected**	**Year(s)/Semester of Data Collection**	**Target for Performance**
Students will successfully complete a laboratory assignment with a pre-lab component, data collection component, and analysis component	Pre-lab assignment Data pages from lab notebook Lab reports	BME 241	Every three years (next: fall 2017)	70% of students will earn a grade of 70% or higher on the lab assignment
Students will use statistical methods to analyze and interpret data	Exam problem	BME 322	Every three years (next: spring 2018)	70% of students will score at least 70% on the assessed problem

Students will determine the minimum number of samples needed to ensure the power of a statistical test	Exam problem	BME 322	Every three years (next: spring 2018)	70% of students will score at least 70% on the assessed problem
Design teams will develop, implement, and evaluate the success of a Verification and Validation plan	Final design reports	BME 491/492	Every three years (next: spring 2018)	80% of teams will score at least 60% of the points on the Verification/Validation section of the design report

Outcome C: Students will demonstrate an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, societal, political, ethical, health and safety, manufacturability, and sustainability.

Performance Indicators	**Method(s) of Assessment**	**Where data are collected**	**Year(s)/Semester of Data Collection**	**Target for Performance**
Students will design (in MATLAB/Simulink) a transfer function to simulate an artificial cochlea with economic constraints on the number of available components	Project report	BME 331	Every three years (next: fall 2017)	70% of students will score at least 70% of points on the assignment
Based on experimental results, students will propose a methodology to design a material to meet specific constraints (e.g. porosity, hardness)	Lab report	BME 383	Every three years (next: fall 2017)	70% of students will earn a grade of 80% or higher on the material design section of the lab
Teams will deliver a working prototype of a design that meets product specifications	Prototype	BME 491/492	Every three years (next: spring 2018)	75% of teams will deliver and test a working prototype
Each team will deliver a product specification, design documentation, test plan and test results, with a focus on meeting relevant FDA or other regulatory standards	Final report	BME 491/492	Every three years (next: spring 2018)	80% of teams will score at least 60% of the points on the Product Specifications and Regulatory Standards section of the report

Outcome D: Students will demonstrate an ability to function on multidisciplinary teams.

Performance Indicators	**Method(s) of Assessment**	**Where data are collected**	**Year(s)/Semester of Data Collection**	**Target for Performance**
Students will demonstrate good citizenship when participating in team projects.	Teamwork assessment forms	BME 222 BME 354	Every three years (next: spring 2018)	70% of students will score an average of at least 2.5 (on a scale of 0-3) on a team citizenship rubric
Students will successfully complete lab assignments in 2-4 person teams (assessed by overall average on all lab assignments and a teamwork rubric)	Laboratory reports	BME 222 BME 354	Every three years (next: spring 2018)	70% of lab groups will score at least 80% on assessed lab reports 100% of assessed team lab reports will include and clearly

				delineate the contributions of each team member
Students will complete a major 2-semester design project as part of a 4-5 member team	Teamwork assessment forms	BME 491/492	Every three years (next: spring 2018)	90% of students will score an average of at least 2.5 (on a scale of 0-3) on a team citizenship rubric 100% of teams will be rated at least "satisfactory" by project sponsors

Outcome E: Students will demonstrate an ability to identify, formulate, and solve engineering problems.

Performance Indicators	Method(s) of Assessment	Where data are collected	Year(s)/Semester of Data Collection	Target for Performance
Students will solve an engineering problem related to mechanics	Exam question	BME 241	Every three years (next: fall 2017)	70% of students will score at least 70% on assessed problem
Students will apply Fourier or Laplace transform concepts to identify, formulate and solve an engineering problem	Exam question	BME 331	Every three years (next: fall 2017)	70% of students will score at least 70% on assessed problem
Students will identify, formulate, and solve engineering problems related to biofluid mechanics	Homework and exam questions	BME 442	Every three years (next: fall 2017)	70% of students will score at least 70% on assessed problems

Outcome F: Students will demonstrate an understanding of professional and ethical responsibility.

Performance Indicators	Method(s) of Assessment	Where data are collected	Year(s)/Semester of Data Collection	Target for Performance
Students will complete an online tutorial on recognizing and avoiding plagiarism and pass a quiz over the material	Online quiz	ENGR 195	Every six years (next: fall 2017)	90% of students will complete the tutorial and pass the quiz
Students will evaluate the ethics of a research protocol according to NIH guidelines	Homework problem and exam question	BME 352	Every three years (next: spring 2018)	80% of students will score at least 80% on the assessed problems
Students will identify ethical issues in case studies and demonstrate familiarity with professional codes of conduct	Case Studies	BME 491/492	Every three years (next: spring 2018)	80% of students will score at least 80% on the assessed problems

Outcome G: Students will demonstrate an ability to communicate effectively.

Performance Indicators	Method(s) of Assessment	Where data are collected	Year(s)/Semester of Data Collection	Target for Performance
Students will write laboratory reports with appropriate formatting, organization, content, and use of figures and tables	Laboratory report	BME 222	Every three years (next: spring 2018)	70% of students will score at a level of at least Satisfactory on a rubric to assess written lab reports
Students will write a project report describing and analyzing neural signaling as modeled by the Hodgkin-Huxley squid axon model	Project report	BME 334	Every three years (next: fall 2017)	70% of students will score at least "satisfactory" on a rubric designed to assess written communication
Students will write final design reports with appropriate formatting, organization, content, and use of figures and tables	Project report	BME 411	Every three years (next: fall 2017)	70% of students will score at least "satisfactory" on a rubric designed to assess written communication
Students will give oral presentations to describe and analyze their final projects	Oral presentation	BME 411	Every three years (next: fall 2017)	70% of students will score at least "satisfactory" on a rubric designed to assess presentations
Students will give an oral presentation proposing a solution to an identified problem in an engineering environment	Oral presentation	TCM 360	Every three years (next: fall 2017)	70% of BME students will score at least "satisfactory" on all assessed items

Outcome H: Students will possess the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Performance Indicators	Method(s) of Assessment	Where data are collected	Year(s)/Semester of Data Collection	Target for Performance
Students will propose designs for a medical device to be used in a third-world country, making note of the constraints imposed by the local environment and infrastructure where the device will be used	Design report	ENGR 196	Every three years (next: fall 2017)	80% of students will score at least 80% on design write-up
Students will propose designs for a pacemaker system for the developing world, making note of elements in common and elements that must be changed when adapting existing designs for the developing world	Exam question	BME 491/492	Every three years (next: spring 2018)	80% of students will score at least 80% on assessed question
Design teams will identify in their product specifications key relevant needs and requirements including (where appropriate) cost, safety, biocompatibility, environmental impact, and user or societal benefit	Design specifications report	BME 491/492	Every three years (next: spring 2018)	75% of teams will appropriately identify these key requirements and their impacts

Students will discuss the expected impact of a proposed solution in the context of the environment where the solution is to be implemented	Oral report	TCM 360	Every three years (next: fall 2017)	70% of students will score at least "satisfactory"

Outcome I: Students will demonstrate a recognition of the need for, and an ability to engage in life-long learning.

Performance Indicators	**Method(s) of Assessment**	**Where data are collected**	**Year(s)/Semester of Data Collection**	**Target for Performance**
Students will reflect on the knowledge and skills they will need to gain to continue to be effective in their chosen field	Written report (personal development plan)	ENGR 195	Every six years (next: fall 2017)	70% of students will score at least 70% of points on the Life-Long Learning section of the PDP
Students will learn LABVIEW independently using tutorials and apply that knowledge to completing a project to build a data acquisition system.	Project report	BME 222	Every three years (next: spring 2018)	70% of students will score at least 70% on the project
Students will demonstrate the ability to learn independently by writing a research paper on a BME-related topic or attending and summarizing three seminars or experiential learning activities.	Written report	BME 402	Every three years (next: spring 2018)	80% of students will score at least 70% on the report
Students will reflect on the knowledge and skills they still want or need to gain after graduation with a bachelor's degree.	Written report (5-year plan)	BME 402	Every three years (next: spring 2018)	90% of students will discuss plans for continued learning and skill development after graduation

Outcome J: Students will demonstrate a knowledge of contemporary issues.

Performance Indicators	**Method(s) of Assessment**	**Where data are collected**	**Year(s)/Semester of Data Collection**	**Target for Performance**
Students will discuss contemporary research and applications of stem cells in tissue engineering and regenerative medicine	Exam question	BME 354	Every three years (next: spring 2018)	80% of students will score at least 80% on assessed question
Teams will perform a background assessment to evaluate the relevance of their design project, its application, and need for the project as part of their concept description	Concept Description report	BME 491/492	Every three years (next: spring 2018)	80% of teams will score at least 70% on the Concept Description report

Outcome K: Students will demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Performance Indicators	Method(s) of Assessment	Where data are collected	Year(s)/Semester of Data Collection	Target for Performance
Students will use the Creo modeling tool to design a 3-D object	Exam questions	ENGR 196	Every three years (next: fall 2017)	80% of students will score at least 80% of total points on the Creo portion of the exam
Students will demonstrate hands-on instrumentation skills. Students will demonstrate competence with Labview.	Lab practical exam Lab Exercises	BME 222	Every three years (next: spring 2018)	70% of students will earn grade of B or higher 70% of students will receive 80%
Students will demonstrate competence with MATLAB programming	Programming assignment	BME 334	Every three years (next: fall 2017)	70% of students will score at least 70% on the assignment
Students will demonstrate facility with numerical methods for solving differential equations	Exam problems	BME 334	Every three years (next: fall 2017)	70% of students will score at least 70% on the problem
Students will use appropriate development and analysis tools for each project; these might typically include Matlab, Labview, Microsoft Project, firmware, software, and web applications development environment	Prototype development and testing presented in report form	BME 491/492	Every three years (next: spring 2018)	75% of teams will successfully complete and test the prototype