Summary of ABET Student Outcomes Assessment, 2017-2018

Bachelor of Science in Chemical Engineering

Chemical and Biomolecular Engineering Department

University of California, Berkeley

June 26, 2018

Executive Summary

This report presents the direct and indirect student outcomes assessment data collected from instructors and students during the 2017-2018 academic year. It is intended for use in department-level curricular continuous improvement efforts, and creates a record for current and future ABET program evaluators and decision makers.

This report follows the approach outlined in the Process: Assessing and Evaluating Attainment of Student Outcomes document adopted January 4, 2013. Part 1 reports the direct measures results by first reviewing the process and then presenting data sampled from the course Outcome Assessment Templates during the 2017-2018 academic year. Part 2 reports the indirect measures results by first reviewing the process and then presenting data from the spring 2018 graduating senior survey, and the 2017-2018 student focus groups (AIChE Student-Faculty Focus Group and Honors Student Tea). Part 3 summarizes the responses and outcomes from the 2016-2017 cycle.

Direct measures from student classwork show good achievement of most outcomes during the 2017-2018 year, but **Outcome e** (problem solving), **Outcome h** (broad education to understand impacts), and **Outcome k** (techniques, skills, and tools) each showed one course work measure in the 50-75% rpass ange that should be reviewed. Survey and focus group responses show that students continue to be confident about their skills and abilities in most Student Outcomes, especially **Outcome a** (apply math, science, engineering) and **Outcome e** (problem solving). They suggest some focus on improvement in **Outcomes c** (design with constraints)**, h** (broad education to understand impacts)**, j** (contemporary issues)**, and k** (techniques, skills, and tools). Students recommend discussion on continued integration of communications (**Outcome g**), and the role of project-based learning.

Part 1: Direct Measures: Student Course Work

Process excerpt:

a. *Each Student Outcome is assessed in at least two core chemical engineering courses that apply the Outcome to a high degree.*
    i. *See Student Outcome-Course Matrix for mapping.*
    ii. *For each Outcome, core courses are chosen from different levels of the curriculum (such as sophomore and senior) so that the development of each Student Outcome may be monitored over time.*
    iii. *Each core course in the curriculum is used to assess at least one Student Outcomes.*

b. *Faculty and graduate student instructors of each course assess student course work and use the course Outcome Assessment Template to report the number of students who fail, pass, or pass with distinction each of the Student Outcomes.*
    i. *Outcome Assessment Templates are also used for course-level outcome assessment.*
    ii. *When a course-level outcome is highly similar to the given Student Outcome, the same measure is used for both.*
    iii. *See Outcome Assessment Templates for Student Outcomes for details.*
    iv. *Outcome Assessment Templates are collected each semester by instructor submission to a specified site in the Berkeley online course management system, administered by the department ABET coordinator.*

c. *In June of each year, the ABET coordinator generates a Quantitative Student Outcome Attainment report using the data from the Outcome Assessment Templates.*
    i. *For each Student Outcome, the lower level course is analyzed in odd calendar years, and the higher level course is analyzed in even calendar years. For example, Student Outcome b is analyzed in 142 (sophomore) in 2013 and in 154 (senior) in 2014.*
    ii. *The Outcome Assessment Template data are used to calculate a percentage pass rate for each Student Outcome.*
    iii. *Trends in pass rate are monitored over time.*

Data: Student Outcomes-Course Matrix:

The Student Outcomes-Course Matrix has been updated to include data from courses on the Fall 2017 and Spring 2018 sampling schedule, in Table 1 below. Grey boxes indicate a course which is sampled in a different semester. Green, yellow, or red boxes contain the percentage of students who passed the outcome as measured in the course. Data collected during the 2017-2018 cycle show strong student achievement of most Outcomes, with some discussion warranted to examine the results for Outcome e (identify, formulate, solve engineering problems), Outcome h (broad education to understand impact of engineering solutions), and Outcome k (use modern engineering tools), all of which have one measure in the "yellow" zone which is not past the action threshold, but with lower achievement than the recent past semesters.

Table 1: June 26, 2018: Analysis of Outcome Assessment Templates for Student Outcomes **% Passing**

ABET Student Outcome	Measure from Outcome Assessment Templates	Year Analyzed	Year of Study	Spring 2013	Fall 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017	Spring 2018
a- An ability to apply knowledge of mathematics, science, and engineering.	**150 A - Transport** - Course Outcome #3: Solve for the velocity field in simple geometries using the differential forms of conservation of mass and linear momentum.	2013, 2015, ...	Junior	96%				94%				82%		
	162 - Process Dynamics and Control - Course Outcome #2: Use principles of chemistry and physics to derive mechanistic process models.	2014, 2016, ...	Senior			84%				96%	70%			92%
b- An ability to design and conduct experiments, as well as to analyze and interpret data.	**142 - Reaction Engineering** - Course Outcome #4: Derive a reaction rate expression from a homogeneous or heterogeneous mechanism by employing most abundant surface intermediate, quasi-equilibrium, and pseudo-steady-state approximations.	2013, 2015, ...	Sophomore		91%				81%				79%	
	154 - Unit Operations Laboratory - Course Outcome #1: Set up and carry out an experimental plan for extracting information about chemical/physical processes.	2014, 2016, ...	Senior			96%	100%			100%	92%			92%
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.	**40 - Intro to Chem Eng Design** - Course Outcome #1: Create a process flow diagram for a chemical or physical process protocol, applying standard process flow diagram conventions including stream labeling and standard names for physical and chemical unit operations.	2013, 2015, ...	Freshman		96%				98%				98%	
	150B - Transport and Separations - Course Outcome #4: Design a binary distillation unit with various design specifications.	2014, 2016, ...	Senior				99%				87%			
	160 - Process Design - Course Outcome #3: Optimize the [process simulation] flowsheet based on heuristics, scheduling considerations, and the results of systematic variation of process parameters in the simulation package.	2014, 2016, ...	Senior			87%	89%			90%	94%			90%
d- An ability to function on multi-disciplinary teams.	**40 - Intro to Chem Eng Design** - NEW item: Function effectively on project teams.	2013, 2015, ...	Freshman		100%				100%				98%	
	154 - Unit Operations Laboratory - NEW item: Function effectively on project teams.	2014, 2016, ...	Senior			96%	100%			92%	95%			95%
	160 - Process Design - NEW item: Function effectively on project teams.	2014, 2016, ...	Senior			97%	100%			91%	97%			90%
e- An ability to identify, formulate, and solve engineering problems.	**141 - Thermodynamics** - Course Outcome #6: Calculate equilibrium composition or conversion in a homogeneous or heterogeneous chemical reaction.	2013, 2015, ...	Sophomore	70%				94%				87%		
	150A - Transport - Course Outcome #5: Find heat transfer coefficients for forced and free convection conditions.	2015*, 2016, ...	Junior					86%		92%				74%
f- An understanding of professional and ethical responsibility.	**185 - Technical Communications** - Course Outcome #8: Recognize the ethical responsibility of engineers, and articulate morally justified solutions to ethical problems.	2013, 2015, ...**	Junior	96%	95%			99%	96%			100%		
	160 - Process Design - Course Outcome # 9: Demonstrate awareness of ethical and contemporary issues related to the design and operation of chemical or biological processes.	2014, 2016, ...	Senior			100%	100%			100%	100%			100%

Color Key:

Grey- No data; course not offered or not on sampling schedule this semester

Green- Over 75% of students passed this outcome by the course direct measure

Yellow- Over 50% of students passed this outcome by the course direct measure

Red- Action level: 50% or fewer of students passed this outcome by course direct measure

Table 1 (Continued): June 26, 2018: Analysis of Outcome Assessment Templates for Student Outcomes

				% Passing										
ABET Student Outcome	**Measure from Outcome Assessment Templates**	**Year Analyzed**	**Year of Study**	**Spring 2013**	**Fall 2013**	**Spring 2014**	**Fall 2014**	**Spring 2015**	**Fall 2015**	**Spring 2016**	**Fall 2016**	**Spring 2017**	**Fall 2017**	**Spring 2018**
g- An ability to communicate effectively.	**185 - Technical Communications** - Course Outcomes #2. Write clearly, directly, and concisely in technical documents.	2013, 2015, ...**	Junior	94%	84%			95%	96%			94%		
	154 - Unit Operations Laboratory - Course Outcome #6: Present technical information effectively.	2014, 2016, ...	Senior			100%	100%			100%	100%			100%
h- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	**142 - Reaction Engineering** - NEW item (from Course Objectives): Analysis and awareness of reactive hazards including but not limited to hot spots and thermal runaway in packed-bed and stirred-tank reactors.	2013, 2015, ...	Junior		49%				96%				81%	
	160 - Process Design - Course Outcome #8: Use profitability measures (such as net present value or Internal Rate of Return) to compare different process optimization schemes.	2014, 2016, ...	Senior			91%	100%			100%	100%			60%
i- A recognition of the need for and an ability to engage in life-long learning.	**40 - Intro to Chemical Engineering Design** - NEW item: Recognize the need for and have an ability to engage in life-long learning.	2013, 2015, ...	Freshman		96%				98%				98%	
	160 - Process Design -NEW item: Recognize the need for and have an ability to engage in life-long learning.	2014, 2016, ...	Senior			96%	100%			100%	100%			100%
j- A knowledge of contemporary issues.	**140 - Chem Process Analysis** - NEW item (from topics covered): Deconstructing chemical accidents, runaway reactors, adiabatic flames.	2013, 2015, ...	Sophomore		74%				85%				93%	
	160 - Process Design - Course Outcome #1: Discuss the principal issues in environmental protection and safety, including reactive hazards, as they relate to the design of new chemical and biological processes and retrofitting older plants.	2014, 2016, ...	Senior			93%	100%			100%	100%			100%
k- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	**140 - Chem Process Analysis** - Course Outcome #2: Perform steady species/element mass balances on chemical processes including multiple reactions, recycle and purge to establish overall conversion, yield, and selectivity.	2013, 2015, ...	Sophomore		58%				95%				85%	
	162 - Process Dynamics and Control - Course Outcome #1: Analytically and computationally solve ordinary differential equations.	2014, 2016, ...	Senior			83%				96%		81%		59%

Color Key:

Grey- No data; course not offered or not on sampling schedule this semester

Green- Over 75% of students passed this outcome by the course direct measure

Yellow- Over 50% of students passed this outcome by the course direct measure

Red- Action level: 50% or fewer of students passed this outcome by course direct measure

*Outcome sampling planned for spring 2014 150A has been rescheduled to 2015 due to an instructional change.

**185 not offered fall 2017 or later.

Part 2: Indirect Measures: Student Survey and Focus Group

Process excerpt:

a. *Graduating seniors are surveyed about the Student Outcomes on the senior graduation survey administered by the College of Chemistry.*
    i. *Graduating seniors are asked to rate the level to which the curriculum prepared them to attain each Student Outcome.*
    ii. *The survey is administered in spring of each year.*
    iii. *Survey completion is required for tickets to the Commencement ceremony.*
    iv. *Survey results are reported to the Chemical and Biomolecular Engineering Department in spreadsheet format by August of the same calendar year.*

b. *Student focus groups occur twice each academic year, giving student representatives a forum to discuss curricular issues with faculty representatives.*
    i. *The AIChE Lunch is each fall semester, with 5-10 students from the Berkeley AIChE Student Section, including officers and non-officers across all years of study.*
    ii. *The Honors Tea is each spring semester, with 10-15 chemical engineering honors students across all years of study.*
    iii. *During these focus groups, students are asked to consider the Student Outcomes and comment on those that the curriculum addresses well, and those that should be improved.*
    iv. *The student feedback is recorded in the meeting minutes.*

Data: Senior Survey:

Graduating seniors were surveyed on the degree to which they agree that they possess each skill or ability described in the Student Outcomes (a-k). There were 76 responses for this year's survey. Their responses are summarized in Table 2, below. A comparison of percentage of student agreeing to each item during 2013, 2014, 2015, 2016, 2017, and 2018 is shown in Figure 1, below.

Table 2: Senior Survey Responses 2018. Students were asked if they have each ability.

Student Outcomes	Disagree		Neutral		Agree		Total
a An ability to apply knowledge of mathematics, science, and engineering	1	1%	6	8%	69	91%	76
b An ability to design and conduct experiments, as well as to analyze and interpret data	0	0%	8	11%	68	89%	76
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	3	4%	23	30%	50	66%	76
d An ability to function on multidisciplinary teams	1	1%	11	14%	64	84%	76
e An ability to identify, formulate, and solve engineering problems	0	0%	9	12%	67	88%	76
f An understanding of professional and ethical responsibility	1	1%	7	9%	68	89%	76
g An ability to communicate effectively	0	0%	10	13%	66	87%	76
h The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	1	1%	18	24%	57	75%	76
i A recognition of the need for, and an ability to engage in life-long learning	1	1%	12	16%	63	83%	76
j A knowledge of contemporary issues (such as energy, water, safety, and food)	4	5%	20	26%	52	68%	76
k An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3	4%	18	24%	55	72%	76

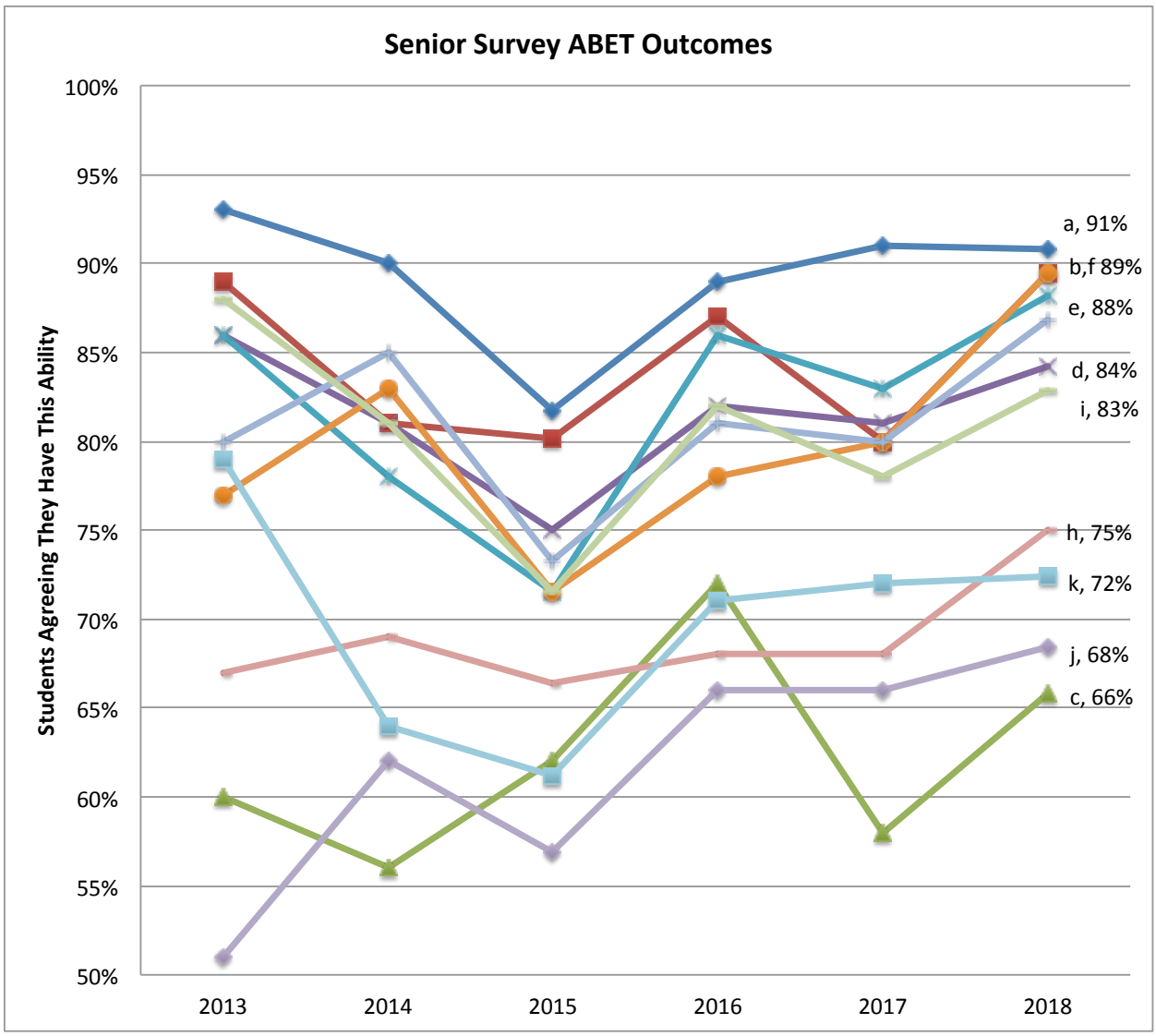

Figure 1: Comparison of Senior Survey Responses from the six years of data collection.

Ratings for each Outcome, a-k are stable or have moderately increased this year compared to last year.

Most items are consistent with last year's results, and many items have been rather stable during the course of the data collection.

Outcome a (an ability to apply knowledge of mathematics, science, and engineering; 91% agree) was rated the highest this year, and has been consistently highest during the five years of surveying the senior students.

There is a modest upward trend in **Outcome j** (a knowledge of contemporary issues), which has received extra attention for improvement in the past few years. The rating is the slightly above last year, with 68% agreeing.

Outcome 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) recovered somewhat compared to last year, but is the lowest-rated outcome this year, with 66% of students agreeing they have this skill.

Outcome h (the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context) climbed to 75% agreeing this year.

Data: Student Outcomes Reflections from the AIChE Student-Faculty Focus Group, November 7, 2017:

Instead of lunch, this year the event was offered as an afternoon tea. Student representatives from the AIChE student chapter responded online with a survey on issue including: core course offerings, electives and concentrations, format of faculty advising, ABET Student Outcomes a-k, and their own ideas. We extended the conversation at the tea.

Reviewing the Student Outcomes a-k:

Students generally find these Outcomes are being addressed by the curriculum.

They address multidisciplinary teamwork mostly in their general education classes.

Item j (contemporary issues) can use more focus. They suggest the syllabi and topics in courses can be updated to reflect more current content.

There is good coverage of ethical responsibility (outcome f) in Chem Eng 185, 140, 142. There has been improvement in this area. Improvement can continue to bring out issues with more subtlety, and less black and white issues.

There is some student concern about communications training (outcome g) with the removal of Chem Eng 185 as a required course. Group projects are good for this. Students are concerned about getting enough writing practice-suggest that when writing is required as a deliverable, the deliverable be graded thoroughly, and worth more points, for communications skills.

Data: Student Outcomes Reflections from the Honors Student Tea, Wednesday, April 18, 2018:

This year's tea included a full-group discussion on issues including the timing of core course offerings (planning to offer all core courses each semester), student support systems like tutoring and counseling services, thermodynamics coverage, communications training, and Student Outcomes a-k specifically.

Responding to Prompt on ABET Student Outcomes:

Students would like to have more projects included in their coursework, such as that in Chem Eng 40.

They noted that Chem Eng 154 carries a heavy burden for development of many outcomes a-k.

Regarding Outcome g (communication), they found that presenting their projects to a GSI audience in Chem Eng 40 was very helpful.

They felt that the curriculum develops outcome e (identify, formulate, solve engineering problems) particularly well.

They responded that the concentrations and minor programs add breadth to the learning (outcome h).

Part 3: Summary of Response to 2016-2017 Cycle

The 2015-2016 continuous improvement cycle identified **Outcomes c** (design with constraints), **h** (broad education to understand impacts), **j** (contemporary issues), and **k** (techniques, skills, and tools) as potential areas of improvement, based largely on student feedback via indirect measures (direct measures showed satisfactory achievement of all objectives in that cycle). The faculty discussed these results at the January 2018 annual Faculty Retreat.

The faculty noted the concern over the drop in **Outcome c**, and discussed the structure and content of the capstone design experience. Faculty committed to continue this emphasis of contemporary issues in their courses, an extension of recent years' effort.

The faculty also discussed at length the curriculum timing and sequence. The faculty has decided to move to offering freshman-junior core courses each semester, following the pattern of junior-senior level core courses. This change will begin with freshman-sophomore courses 40 and 140 in 2018-2019. The change accompanies a change to require 40 for all transfer students. This creates a new, common knowledge base for students entering 140. Coordination of the 40, 140, and 141 courses will be implemented to adjust for this change. Thermodynamics content, timing, and delivery across multiple courses was discussed, to ensure that students are getting an optimum degree of complementarity in the various courses. These changes are integral with student outcome achievement. The faculty has also decided to adopt the new ABET standard Student Outcomes 1-7, beginning the 2018-2019 academic year.