Summary of ABET Student Outcomes Assessment, 2016-2017

Bachelor of Science in Chemical Engineering

Chemical and Biomolecular Engineering Department

University of California, Berkeley

December 31, 2017

Executive Summary

This report presents the direct and indirect student outcomes assessment data collected from instructors and students during the 2016-2017 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 2016-2017 academic year. Part 2 reports the indirect measures results by first reviewing the process and then presenting data from the spring 2017 graduating senior survey, and the spring 2017 student focus groups (AIChE Student Lunch and Honors Student Tea). Part 3 summarizes the responses and outcomes from the 2015-2016 cycle.

Direct measures from student classwork show strong achievement of outcomes during the 2016-2017 year. 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). 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). Therefore, faculty discussion at the next retreat will focus on **Outcomes c, h, j, and k**, to generate strategies for continued improvement.

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 2016 and Spring 2017 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 2016-2017 cycle show strong student achievement of Outcomes.**

Table 1:December 31, 2017: Analysis of Outcome Assessment Templates for Student Outcomes

ABET Student Outcome	Measure from Outcome Assessment Templates	Year Analyzed	Year of Study	% Passing Spring 2013	Fall 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017
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%		99%
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%			
	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%	
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%			
	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%	
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%			
	154 - Unit Operations Laboratory - NEW item: Function effectively on project teams.	2014, 2016, ...	Senior			96%	100%			92%	95%	
	160 - Process Design - NEW item: Function effectively on project teams.	2014, 2016, ...	Senior			97%	100%			91%	97%	
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%		
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%	

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): December 31, 2017: Analysis of Outcome Assessment Templates for Student Outcomes

ABET Student Outcome	Measure from Outcome Assessment Templates	Year Analyzed	Year of Study	% Passing Spring 2013	Fall 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017
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%	
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%			
	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%	
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%			
	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%	
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%			
	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%	
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%			
	162 - Process Dynamics and Control - Course Outcome #1: Analytically and computationally solve ordinary differential equations.	2014, 2016, …	Senior			83%				96%		81%

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 has been rescheduled to 2015 due to an instructional change.

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 86 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, and 2017 is shown in Figure 1, below.

Table 2: Senior Survey Responses 2017. 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%	7	8%	78	91%	86
b An ability to design and conduct experiments, as well as to analyze and interpret data	1	1%	16	19%	69	80%	86
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	3%	33	38%	50	58%	86
d An ability to function on multidisciplinary teams	3	4%	13	15%	69	81%	85
e An ability to identify, formulate, and solve engineering problems	1	1%	14	16%	71	83%	86
f An understanding of professional and ethical responsibility	0	0%	17	20%	68	80%	85
g An ability to communicate effectively	4	5%	13	15%	67	80%	84
h The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	6	7%	21	25%	58	68%	85
i A recognition of the need for, and an ability to engage in life-long learning	4	5%	15	17%	67	78%	86
j A knowledge of contemporary issues (such as energy, water, safety, and food)	7	8%	22	26%	57	66%	86
k An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	7	8%	17	20%	62	72%	86

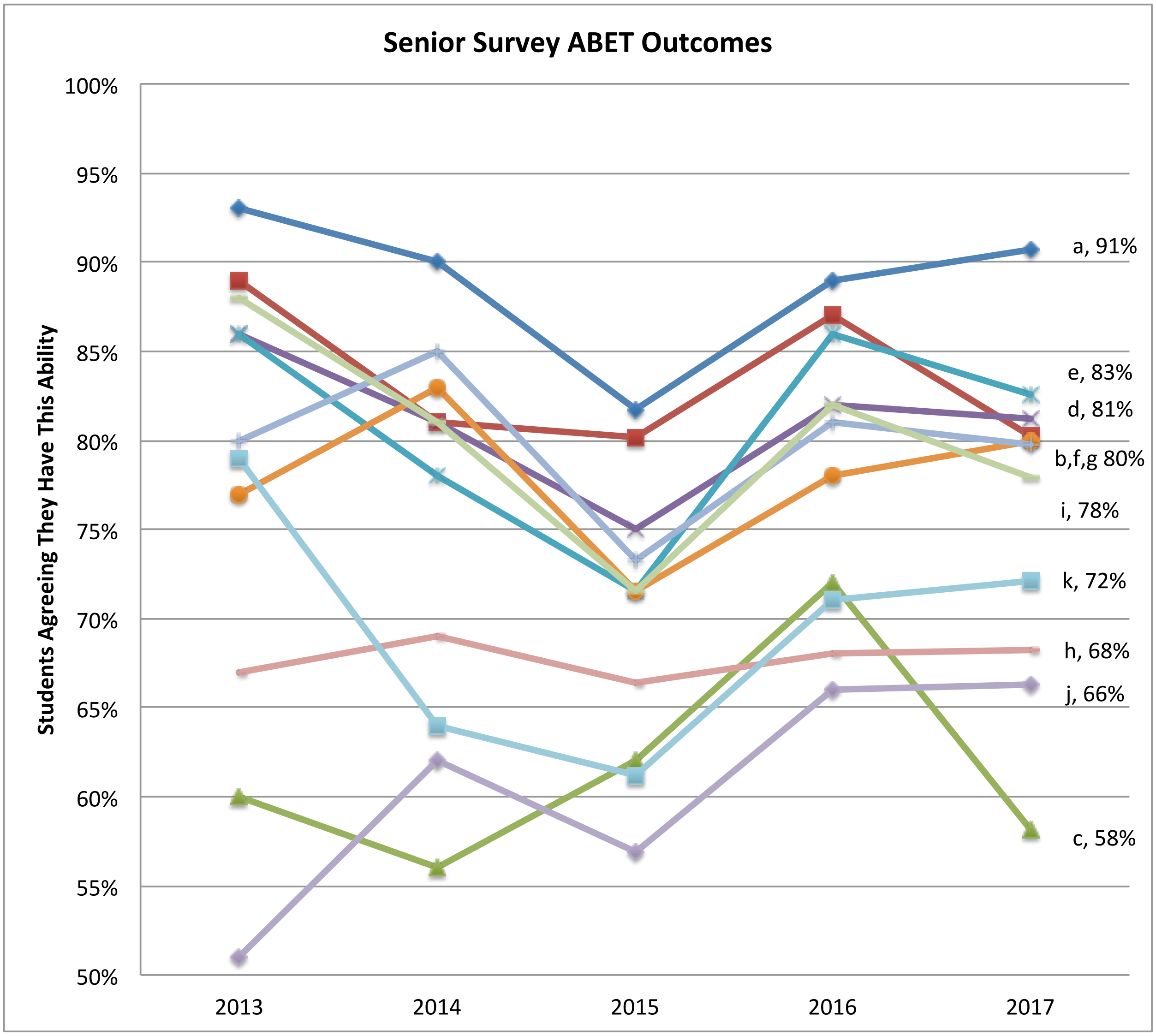

Figure 1: Comparison of Senior Survey Responses from the five years of data collection.

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 same this year as last year, stable at 66% agreeing.

However, **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) dropped this year to 58% of students agreeing, after having climbed for a few years:

- 60%, 56%, 62%, 72%, 58%

Outcome h (the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; 68% agree) continues to be among the lowest rated items during the past five years of data collection, and is stable compared to last year.

Data: Student Outcomes Reflections from the AIChE Student Lunch, March 21, 2017:

For this year's lunch, student representatives volunteered with specific issues they wished to discuss. Office hours, tutoring for upper-division CBE courses, and faculty engagement at events were topics students submitted for discussion. Students also reflected directly on the Student Outcomes a-k. Points relating to the Student Outcomes a-k are the following, suggestions for improvement marked in *red italics*:

- **Outcome a** (an ability to apply knowledge of mathematics, science, and engineering)
  - 154 and 160 do a good job with real-world constraints and application.
- **Outcome b** (an ability to design and conduct experiments, as well as to analyze and interpret data)
  - Chem 4A and 4B special projects are a chance to test something of interest. *Students would like more* of that.
- **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)
  - 154 and 160 do a good job with real-world constraints and application.
- **Outcome d** (an ability to function on multidisciplinary teams)
  - 140, 185 help with teams and design projects
- **Outcome k** (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice)
  - *Students would like exposure to equipment earlier in the curriculum*.
  - Students are not sure if the programs like ASPEN they use in class are useful for industry.

Data: Student Outcomes Reflections from the Honors Student Tea, Thursday, March 9, 2017:

This year's tea invited students to self-assemble around discussion prompts ranging from prospective online and summer course offerings, areas for most crucial improvement, to specific questions about the curriculum. Each group addressed two of the Student Outcomes a-k specifically, each group reported a summary, and a global discussion was had about the responses.

Discussion Prompt:

ABET Student Outcomes: How are we doing on these skills?

Students responded overall that the objectives are being met, but offered some suggestions for improvement, marked with *red italics*:

- **Outcome a** (an ability to apply knowledge of mathematics, science, and engineering)
  - Problem sets are real-world oriented.
- **Outcome b** (an ability to design and conduct experiments, as well as to analyze and interpret data)
  - The curriculum offers many opportunities for this, including Chem 4B, Chem 112A, ChemE 40, 140, 162, E 45L
- **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)
  - Chemical Engineering 160 does a fine job with realistic constraints.
  - *Students want more options for the design final projects*.
- **Outcome d** (an ability to function on multidisciplinary teams)
  - *More effort or opportunity for CBE students to work with students of other majors*
- **Outcome e** (an ability to identify, formulate, and solve engineering problems)
  - Chemical Engineering 40 introduced this well with use of Excel
- **Outcome f** (an understanding of professional and ethical responsibility)
  - Significant exposure to green chemistry ethics enhances this.
  - Professional panel session in Chemical Engineering 40 demonstrated professional aspects.
- **Outcome g** (an ability to communicate effectively)
  - Oral presentations in 40, 185, and 154 all contribute to these skills.
  - *Presentations in 160 need more feedback on how to improve*.
- **Outcome h** (the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context)
  - Final projects in Chemical Engineering 40 develop this
- **Outcome i** (a recognition of the need for, and an ability to engage in life-long learning)
  - Interactions with Graduate Student Instructors give insights into graduate school
  - Project-based learning helps to develop this in several classes
- **Outcome j** (a knowledge of contemporary issues)
  - Exposure to *contemporary issues is present, but not well-integrated into course materials.*
  - The Chem 4A focus on green chemistry contributes.

- **Outcome k** (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice)
    - *Integrate lab courses and practical applications in the curriculum earlier than Chemical Engineering 154 in the junior/senior year*
    - The practical skills taught in Chemical Engineering 185 are useful
    - *Apply MATLAB more consistently across core courses, not just in E7*.

Part 3: Summary of Response to 2015-2016 Cycle

The 2015-2016 continuous improvement cycle identified Outcomes **h** (broad education to understand impacts), **j** (contemporary issues), safety (**c**), ethics (**f**), multidisciplinary teamwork (**d**), and co-curricular learning (**i**) 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 2017 annual Faculty Retreat.

The faculty discussed the fact that some of these items are difficult to measure, and we acknowledged that the pending changes to ABET Student Outcomes will affect those items specifically. Faculty were encouraged to continue this emphasis of contemporary issues in their courses, an extension of last year's effort.