Summary of ABET Student Outcomes Assessment, 2013-2014

Bachelor of Science in Chemical Engineering

Chemical and Biomolecular Engineering Department

University of California, Berkeley

June 30, 2014

Executive Summary

This report presents the direct and indirect student outcomes assessment data collected from instructors and students during the 2013-2014 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 2013-2014 academic year. Part 2 reports the indirect measures results by first reviewing the process and then presenting data from the spring 2014 graduating senior survey, and the fall 2013 student focus group (AIChE Student Lunch). Part 3 summarizes the responses and outcomes from the 2012-2013 cycle.

Student coursework direct measures identify **Outcome h** (the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context) as an area for improvement. Senior exit survey indirect measures identify **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), **Outcome j** (knowledge of contemporary issues)**, and Outcome k** (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice) for discussion and improvement. **Outcomes c, h, and k** will be discussed at an August or September faculty meeting. Results show modest improvement of **Outcome j** (knowledge of contemporary issues), a target area identified in the 2012-2013 cycle. Strategies for improvement in this area will continue to be implemented.

<u>Part 1: Direct Measures: Student Course Work</u>

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 2013 and Spring 2014 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. **These data indicate one item, Outcome h (the broad education necessary to understand the impact of engineering solutions in a global economic, environmental, and societal context), as measured in the Fall 2013 Reaction Engineering course, as below our action**

threshold of 50% or lower pass rate. This item will be discussed in an August or September 2014 faculty meeting. We will continue to monitor all direct data from courses.

Table 1: June 30, 2014: 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
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%		
	162 - Process Dynamics and Control - Course Outcome #2: Use principles of chemistry and physics to derive mechanistic process models.	2014, 2016, ...	Senior			84%
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%	
	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%
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 #4: 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%	
	150B - Transport and Separations - Course Outcome #4: Design a binary distillation unit with various design specifications.	2014, 2016, ...	Senior			
	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%
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%	
	154 - Unit Operations Laboratory - NEW item: Function effectively on project teams.	2014, 2016, ...	Senior			96%
	160 - Process Design - NEW item: Function effectively on project teams.	2014, 2016, ...	Senior			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%		
	150A - Transport - Course Outcome #5: Perform energy balances on macroscopic control volumes using heat transfer coefficients.	2015*, 2016, ...	Junior			
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%	
	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%

Table 1 (Continued): June 30, 2014: 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**
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%	
	154 - Unit Operations Laboratory - Course Outcome #6: Present technical information effectively.	2014, 2016, ...	Senior			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%	
	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%
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%	
	160 - Process Design -NEW item: Recognize the need for and have an ability to engage in life-long learning.	2014, 2016, ...	Senior			96%
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%	
	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%
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%	
	162 - Process Dynamics and Control - Course Outcome #1: Analytically and computationally solve ordinary differential equations.	2014, 2016, ...	Senior			83%

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 resscheduled 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). The survey responses from approximately 80 graduating seniors are compiled in Table 2, below.

Student responses were especially positive on outcomes:

- **Outcome a** (an ability to apply knowledge of mathematics, science, and engineering; 90% agree)
- **Outcome g** (an ability to communicate effectively; 85% agree)
- **Outcome f** (an understanding of professional and ethical responsibility; 83% agree)

The survey also identifies potential opportunities for increasing students' skills in outcomes:

- **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; 56% agree; 8% disagree)
- **Outcome j** (a knowledge of contemporary issues; 62% agree; 17% disagree)

- **Outcome k** (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice; 64% agree; 10% disagree)

Compared to survey responses from 2013, most items were relatively unchanged (number of students agreeing was within 10% of the previous year's responses), but

- **Outcome j** (a knowledge of contemporary issues) was **up 11%** compared to 2013
- **Outcome k** (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice) was **down 15%** compared to 2013

Table 2. College of Chemistry Exit Survey Spring 2014 Results

If your major is Chemical Engineering, or any Chemical Engineering joint major, please answer this question. If your major is Chemistry or Chemical Biology, please skip to question 16. For each of the statements below, please indicate the degree to which you agree that you possess this skill or ability:

ABET Statements:	Response Count	Disagree	Neutral	Agree		Change from 2013
		# responding	# responding	# responding	% of total	% of total
a-An ability to apply knowledge of mathematics, science, and engineering	77	1	8	69	90%	-3%
b-An ability to design and conduct experiments, as well as to analyze and interpret data	78	2	13	63	81%	-8%
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	78	6	28	44	56%	-4%
d-An ability to function on multidisciplinary teams	78	2	13	63	81%	-5%
e-An ability to identify, formulate, and solve engineering problems	78	6	11	61	78%	-8%
f-An understanding of professional and ethical responsibility	78	3	10	65	83%	+6%
g-An ability to communicate effectively	78	0	12	66	85%	+5%
h-The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	78	4	20	54	69%	+2%
i-A recognition of the need for, and an ability to engage in life-long learning	78	2	13	63	81%	-7%
j-A knowledge of contemporary issues	78	13	17	48	62%	+11%
k-An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	78	8	19	50	64%	-15%

Data: Student Outcomes Reflections from the AIChE Student Lunch, November 18, 2013

Students discussed a wide variety of curricular topics with faculty at the AIChE Student Lunch. Reflections relating directly to the Student Outcomes a-k including the following:

- **Outcome j (knowledge of contemporary issues):** Contemporary issues were done well, particularly by Professor Reimer, and were helpful.
- **Outcome b (ability to design and conduct experiments, analyze and interpret data):** Design and analysis of data are done well, but students wish for more material on design of experiments.
- **Outcome d (ability to work on multidisciplinary teams**): Students were confident of their ability to work on multidisciplinary teams.

Data: Student Outcomes Reflections from the Honors Student Tea, April 29, 2013:

Honors students discussed a wide variety of curricular and departmental topics with faculty at the Honors Student Tea, focusing on individual courses. They did not comment on the Student Outcomes a-k. In future Honors Student Teas, as in the 2013 Tea, students will be asked directly to respond to these Student Outcomes.

Strategies for improving student indirect measures on Outcomes c and k will be discussed at an August or September 2014 faculty meeting.

Part 3: Summary of Response to 2012-2013 Cycle

The 2012-2013 continuous improvement cycle identified Outcome j (a knowledge of contemporary issues) as an action item based on indirect measures. The faculty met on September 4, 2013 to discuss and address this item. We are in the process of implementing changes in response to this item.

Faculty response to Student Outcomes assessment results, September 4, 2013 Faculty Meeting:

We define the scope of "a knowledge of contemporary issues" necessary for the education of new chemical engineering professionals to include an awareness of important societal issues such as sustainable energy and water production; environmental, health, and safety issues; and the needs of the developing world; and an understanding of how chemical engineering impacts and provides tools to contribute to the solution of these issues.

We already integrate student training in these issues into our core curriculum through the use of examples and case studies focusing on energy, safety, and other contemporary issues, and we offer elective courses specially targeted to these issues, such as CBE 90: Science and Engineering of Sustainable Energy, C195A/C295A: The Berkeley Lectures on Energy: Energy from Biomass, and C295Z. Energy Solutions: Carbon Capture and Sequestration.

In order to improve our students' knowledge of contemporary issues, we will employ the following strategies:

1) All instructors of CBE courses, core and elective, will be more explicit about addressing chemical engineering applications to contemporary issues in their courses, so that these connections may be clearer to students.

2) The Department will sponsor a speaker series through the AIChE student group to host industry guest speakers on the topic of Contemporary Issues in Chemical Engineering.

3) The senior survey will be modified to clarify the scope of contemporary issues in question by adding a parenthetical "(such as energy, water, safety, food)" to the survey item on knowledge of contemporary issues.

Follow-up on Knowledge of Contemporary Issues, June 24, 2014:

Action item 1) has been implemented in all courses, with instructors aiming to clarify and emphasize connections between coursework and contemporary issues.

Action item 2) is planned for Fall 2014. During Spring 2014, there was a series of three Student Leadership Seminars led by distinguished alum Mike Cheng.

Action item 3) has been implemented for Spring 2015 surveys.

Exit survey responses indicated a modest improvement, with 62% of students agreeing that they possess knowledge of contemporary issues (compared to 51% last year).

The fall 2013 Student focus group (AIChE Lunch) reported positively on inclusion of contemporary issues during classes.

Direct measures of student performance in courses to assess knowledge of contemporary issues showed medium to high levels, with 74% of students passing the item measured in sophomore course CBE 140 and 93% of student passing the item measured in senior process design course CBE 160.