Summary of ABET Student Outcomes Assessment, 2014-2015

Bachelor of Science in Chemical Engineering

Chemical and Biomolecular Engineering Department

University of California, Berkeley

July 20, 2015

Executive Summary

This report presents the direct and indirect student outcomes assessment data collected from instructors and students during the 2014-2015 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 2014-2015 academic year. Part 2 reports the indirect measures results by first reviewing the process and then presenting data from the spring 2015 graduating senior survey, and the fall 2014 and spring 2015 student focus groups (AIChE Student Lunch and Honors Student Tea). Part 3 summarizes the responses and outcomes from the 2013-2014 cycle.

While direct measures from student classwork show strong achievement of outcomes during the 2014-2015 year, results from the senior survey warrant discussion. In particular, **Outcomes c** (design with constraints), **j** (contemporary issues), and **k** (modern engineering tools) were rated lowest among the outcomes this year and last year, with around 60% of surveyed seniors (N=116) agreeing that they have these abilities. Also worth discussing are the declining responses for outcomes **a** (apply math, science, engineering), **d** (multidisciplinary teams), **e** (solve engineering problems), **i** (life-long learning), and again **k** (modern engineering tools). Each of these has monotonically dropped at least 10 percentage points during the 2013-2015 period. **Outcomes d, i, j,** and **k** sparked the most conversation, questions, and suggestions during student focus groups. This has a strong overlap with the lowest-rated survey outcomes, underscoring the need to address these outcomes with students.

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 2014 and Spring 2015 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 2014-2015 cycle show strong student achievement of Outcomes.**

Table 1:July 20, 2015: 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
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%
	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%	100%	
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				99%	
	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%	
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%	100%	
	160 - Process Design - NEW item: Function effectively on project teams.	2014, 2016, …	Senior			97%	100%	
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%
	150A - Transport - Course Outcome #5: Find heat transfer coefficients for forced and free convection conditions.	2015*, 2016, …	Junior					86%
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%
	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%	

Table 1 (Continued): July 20, 2015: 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
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%
	154 - Unit Operations Laboratory - Course Outcome #6: Present technical information effectively.	2014, 2016, ...	Senior			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%			
	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%	
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%	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%			
	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%	
k- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	**140 - Chem Process Analysi**s - 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). There were 116 respondents for this year's survey, up from 80 last year. Their responses are summarized in Table 2, below. A comparison of percentage of student agreeing to each item during 2013, 2014, and 2015 is shown in Figure 1, below.

Outcomes a and b were rated the highest this year, and have been consistently high during the three years of surveying the senior students:

- **Outcome a** (an ability to apply knowledge of mathematics, science, and engineering; 82% agree)
- **Outcome b** (an ability to design and conduct experiments, as well as to interpret experimental data; 80% agree)

The Outcomes that were identified last year as points of concern due to the lowest percentage of students agreeing are also the lowest rated this year:

- **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; 62% agree; 9% disagree)
- **Outcome j** (a knowledge of contemporary issues; 57% agree; 8% disagree)
- **Outcome k** (an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice; 61% agree; 9% disagree)

In the faculty's discussion of the 2013-2014 cycle data, we did not choose to take any action based on the data, but it merits another discussion with the results from multiple years that show this is a pattern in student perceptions of their abilities.

When we look to the three-year trends, we can expect some fluctuation, and many items remain within 10 percentage points from year to year. However, it may be cause for concern that the following items have dropped at least 10 percentage points monotonically during the three years:

- **Outcome a** (an ability to apply knowledge of mathematics, science, and engineering)
    - 93%, 90%, 82%
- **Outcome d** (an ability to function on multidisciplinary teams)
    - 86%, 81%, 75%
- **Outcome e** (An ability to identify, formulate, and solve engineering problems)
    - 86%, 78%, 72%
- **Outcome i** (A recognition of the need for, and an ability to engage in life-long learning)
    - 88%, 81%, 72%
- **Outcome k** (An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice)
    - 79%, 64%, 61%

Table 2: Senior Survey Responses. 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	3	3%	18	16%	94	82%	115
b An ability to design and conduct experiments, as well as to analyze and interpret data	4	3%	19	16%	93	80%	116
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	11	9%	33	28%	72	62%	116
d An ability to function on multidisciplinary teams	4	3%	25	22%	87	75%	116
e An ability to identify, formulate, and solve engineering problems	4	3%	28	24%	83	72%	116
f An understanding of professional and ethical responsibility	4	3%	29	25%	83	72%	116
g An ability to communicate effectively	3	3%	27	23%	85	73%	116
h The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	11	9%	28	24%	77	66%	116
i A recognition of the need for, and an ability to engage in life-long learning	7	6%	26	22%	83	72%	116
j A knowledge of contemporary issues (such as energy, water, safety, and food)	9	8%	41	35%	66	57%	116
k An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	10	9%	35	30%	71	61%	116

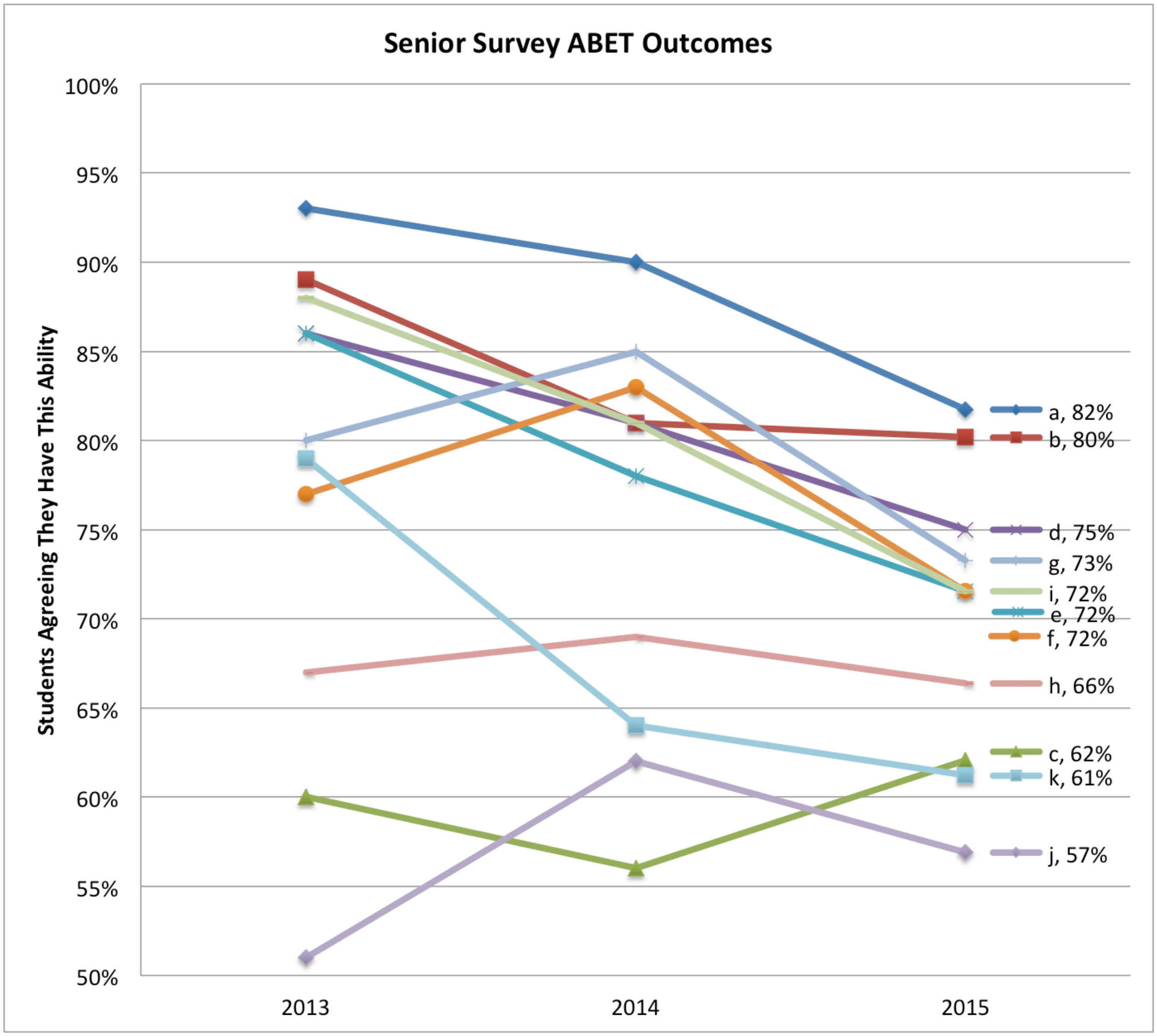

Figure 1: Comparison of Senior Survey Responses from the three years of data collection.

Data: Student Outcomes Reflections from the AIChE Student Lunch, November 14, 2014

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 a (ability to apply knowledge of mathematics, science, engineering**): This is done well in the curriculum.
- **Outcome b (ability to design and conduct experiments, analyze and interpret data):** Students get this from 154, and Chem 4B projects.
- **Outcome d (ability to work on multidisciplinary teams**): Some students were not sure that they had been challenged to work on multidisciplinary teams, while others pointed to team projects in courses such as E7, Physics 7A and 7B, Chem Eng 90, and club experiences as examples of effective teaming with non-ChemEs.
- **Outcome j (knowledge of contemporary issues):** Students would like professors to share more of their interest in contemporary issues that relate to course content. Suggestions included sharing an interesting relevant article through the bCourses announcements, talking more about their research passions such as energy.
- **Outcome k (ability to use techniques, skills, and modern engineering tools necessary for engineering practice):** Students focused on the software aspect of this. Generated a lot of discussion about learning software tools. Some felt the curriculum does a good job of working with COMSOL, MATLAB, ASPEN. Others were eager for deeper use of these tools, and were excited about the 195 computation/modeling course (now 143).

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

ABET a-k

- Students find the prompts repetitive, vague, and overall confusing
- Consensus is that "everything a-k happens in 154/160"

a.
b. (154 does a good job of a-c)
c.
d. What does multidisciplinary mean? We haven't practiced, but we probably can do it.
e. No comments
f. Good examples of professional and ethical responsibility in 185, but could use them more in other courses.
g. No comments
h. No comments
i. Lots of discussion about life-long learning sparked here:
    - Give us skills on how to use Web of Science etc. to find journal articles
    - Give us more up-to-date journal articles (i.e. in 154 labs)
    - Have junior/senior seminars so we can continue to learn new topics
    - Form an undergrad journal club moderated by a faculty member

j. No comments

k. Use of modern engineering tools perceived to mean Aspen/COMSOL. Students feel that there's a steep learning curve, but once through that, they have confidence to tackle all sorts of technology.

Part 3: Summary of Response to 2013-2014 Cycle

The 2013-2014 continuous improvement cycle identified Outcomes c, k, and h for discussion based on direct and indirect measures. The faculty met on February 11, 2015 to discuss and address this.

Faculty response to Student Outcomes assessment results, February 11, 2015 Faculty Meeting:

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, safety, manufacturability, and sustainability

Measured in 40, 150B, 160 Results are fine on these

Student self-assessment of skill is lower at 58% agreeing they have this ability.

Faculty response: Real-world experience will build these skills, and awareness of all these real constraints. Students are trained explicitly to include economic constraints. Emphasis has to be part of the design perspective. It is possible that doing an optimization in 160 could help this issue, but that might be too much to pack into one semester design experience. Final projects in Chem Eng 40 do include constraints for sustainability, economics. Students engage with these. Chem Eng 160 has recently had adjustments to include even more of these, and there may be a time lag to see graduates who have done this. The faculty decided to continue to monitor this to see if there is a change in student self-assessment in the future.

Outcome k: an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Measured in 140, 162 Somewhat low on 140, fine for 162 measure

Student self-assessment of skill is at 64% agree

Faculty response: Students are doing fine on this metric. No action required.

Outcome h: the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Measured in 142, 160. Okay in 160, but very low measure of 49% in 142.

Student Self-assessment at 69%

Faculty response: Group II Breadth Electives should give students exposure to a broad education. We do not have confidence in the 49% reported for the homework problem in 142, based on information from the instructors that many students did not complete this homework set. The faculty recommend that exam metrics are preferred to homework problem metrics for Outcome Assessment Templates, to ensure that the students actually perform at their level for these.