

Outcome 7. Graduates will understand the safety and environmental consequences of their work as chemical engineers and be able to design safe processes.

This outcome maps to ABET Criterion 3 i

Course	Performance indicators
ChE 201, 202, 310, 311, 312, 315, 320, 325, 455, 456	Graduates will be familiar with chemical process safety, HAZOP, life-cycle analysis, the environmental impact of chemical engineering.
	Graduates will be able to design processes both for safety and for economy.

Tools used: Yearlong Design Project Rubric, Design Rubric

Data Collection: The data are collected every semester based on the course offerings.

Frequency of data collection: The data are collected every time courses are taught.

Data Analysis: The data obtained are analyzed every year.

Closing the loop: This outcome is subject to review every year based on performance criteria and metrics and specific action items are developed, if necessary, to revise the content of the courses. The analyzed data are presented separately to the following groups in meetings.

- a) Faculty
- b) Advisory Board

Performance criteria and metrics:

- a) For performance indicator 3-1, students should reach a level of proficiency defined as a goal metric value of 3.0 based on the Yearlong Design Project Rubric scale of 1-4.
- b) For performance indicator 3-2, students should reach a level of proficiency defined as a goal metric value of 2.8 based on the Design Rubric scale of 0-4.

Assessment Tool:

Yearlong Design Project Rubric

Yearlong Design Project Rubric

Attribute	1-Not proficient	2-Progressing to proficiency	3-Proficient	4-Superior proficiency	Score
Design of equipment, Understand interrelationship between equipment in process					
Design of individual equipment	major errors in individual equipment design	some errors in equipment design	equipment designed correctly	unique aspects of equipment design enhance result	
Understand interrelationship between equipment on flowsheet	no understanding of equipment interrelationship	minimum understanding of equipment interrelationship	clear understanding of equipment interrelationship	exploitation of equipment interrelationship to enhance result	
Constraints/limitations of individual equipment and flowsheet understood	constraints/ limitations not understood	not all constraints/ limitations understood	constraints/ limitations clearly understood	exploitation of constraints/ limitations to enhance result	
Significance of conclusions understood	lack of understanding, no explanations	gaps in understanding, few explanations	clear understanding and explanations	superior understanding with in-depth explanations	
Apply chemistry, math, physics, life science, engineering science					
Apply engineering science	inability to apply principles	a few basic principles applied	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to complete design	

Attribute	1-Not proficient	2-Progressing to proficiency	3-Proficient	4-Superior proficiency	Score
Apply chemistry	inability to apply principles	a few basic principles applied	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to complete design	
Apply physics	inability to apply principles	a few basic principles applied	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to complete design	
Apply life science	inability to apply principles	a few basic principles applied	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to complete design	
Apply mathematics	inability to apply principles	a few basic principles applied	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to complete design	
Response to questions indicates ability to apply these principles	response to questions demonstrates inability to apply these principles	response to questions shows application of a few basic principles	response to questions shows clear ability to apply most principles and to understand effect on design	response to questions shows superior ability to apply these principles, which are interwoven with engineering to complete design	
Apply economic, physical constraints and					

Attribute	1-Not proficient	2-Progressing to proficiency	3-Proficient	4-Superior proficiency	Score
optimization methods to obtain solution					
Show ability to use economics to drive solution to problem and focus on important parameters	economics not used to drive solution or to define key parameters	economics sparingly used to drive solution and to define key parameters	economics used to drive solution and to define key parameters	superior solution obtained by unique use of economics	
Define appropriate objective function	appropriate objective function not used	poorly-defined objective function used	correct objective function used	unique objective function used to obtain unique solution	
Define appropriate decision variables	inappropriate or no decision variables used	not all key decision variables used	correct decision variables used	unique decision variables used to obtain unique solution	
Correct use of optimization techniques	correct optimization techniques not used	errors in optimization methodology	correct/reasonable optimization methodology	superior optimization strategy yields unique solution	
Use of computer-based and other information systems	not used	omission of articles, books, etc., not available on web	uncover information from web, books, journals, etc.	uncover all pertinent information from web, books, journals, etc.	
Demonstrate ability to learn new material not taught in class	not demonstrated	reluctant to uncover and use material not taught in class, over dependence on Web-based material	uncovered and synthesized some new material and applied to project	willingly uncovered and synthesized needed new material and applied to project	
Demonstrate ability to function in assigned role					

Attribute	1-Not proficient	2-Progressing to proficiency	3-Proficient	4-Superior proficiency	Score
group member	delinquent in completing tasks	does assigned tasks and little more, often submits work late	participates in group assignments, occasionally goes beyond assigned tasks, usually submits work on time	enthusiastically participates in group assignments, routinely goes beyond assigned tasks, always submits work on time	
group leader	distributes work unevenly or does not distribute work at all, seeks no input from group, no coordination with other group leaders, does not synthesize information and is unprepared for client meetings	distributes work unevenly, seeks little input from group, coordinates poorly with other group leaders, does not synthesize information and is occasionally unprepared for client meetings	distributes work more or less evenly, usually seeks input from group, coordinates somewhat with other group leaders, synthesizes some information and is prepared for client meetings	distributes work evenly, actively seeks input from group, coordinates well with other group leaders, synthesizes information and is well prepared for client meetings	
chief engineer	unable to see big picture, does not delegate responsibilities, little or no communication with class, poor interactions with client and VP for research, will not make difficult decision when needed	difficulty seeing big picture, poor delegation of responsibilities, little communication with class, poor interactions with client and VP for research, reluctant to make difficult decision when needed	sees big picture, seeks input from group leaders, keeps class informed regarding project progress, treats group leaders and group members fairly, satisfactory interactions with client and VP for	sees big picture clearly, consistently seeks input from group leaders, consistently keeps class informed regarding project progress, treats group leaders and group members fairly, interacts well with	

Attribute	1-Not proficient	2-Progressing to proficiency	3-Proficient	4-Superior proficiency	Score
			engineering, is willing to make difficult decisions regarding personnel assignments and evaluations	client and VP for engineering, is willing and able to make difficult decisions regarding personnel assignments and evaluations	
Demonstration of ethical and professional behavior					
in dealings with peers	consistent unprofessional behavior, lying, cheating, backstabbing, disrespect for peers	generally treats peers professionally and in a forthright manner but minor occurrences of unprofessional behavior, lying, cheating, backstabbing, disrespect for peers	always treat peers professionally and in a forthright manner		
in use of information	uses work of others as own work (plagiarism)	does not always acknowledge source of information	always acknowledges source of information appropriately		
Demonstrate understanding of societal impact and need for assigned design					
inclusion of safety-related content	total ignorance of safety-related issues	reluctantly recognizes and includes relevant	usually recognizes and includes relevant	always recognizes, anticipates, and includes relevant	

Attribute	1-Not proficient	2-Progressing to proficiency	3-Proficient	4-Superior proficiency	Score
		safety-related design issues	safety-related design issues	safety-related design issues	
inclusion of environmentally related content	total ignorance of environmentally related issues	reluctantly recognizes and includes relevant environmentally related design issues	usually recognizes and includes relevant environmentally related design issues	always recognizes, anticipates, and includes relevant environmentally related design issues	
understanding of environmental impact of design	neither synthesizes nor demonstrates understanding of environmental impact	occasionally synthesizes and demonstrates understanding of environmental impact	usually synthesizes and demonstrates understanding of environmental impact	always synthesizes and demonstrates understanding of environmental impact	
understanding of legal issues associated with design	neither synthesizes nor demonstrates understanding of legal issues	occasionally synthesizes and demonstrates understanding of legal issues	usually synthesizes and demonstrates understanding of legal issues	always synthesizes and demonstrates understanding of legal issues	

Assessment Tool:

Design Rubric

Design Rubric

Attribute	0 (F) – Not proficient	1 (D) – Less than desired proficiency	2 (C) – Marginal proficiency	3 (B) – Good proficiency	4 (A) – Superior proficiency	Score
Design of equipment, analysis of performance of existing equipment, understand interrelationship between equipment in process						
Design of individual equipment	unable to design equipment	significant errors in equipment design	some errors in equipment design but generally correct	equipment designed correctly	equipment designed correctly and with creativity	
Understand interrelationship between equipment on flowsheet	no understanding of equipment interrelationship	understands interrelationship between a few pieces of equipment	understands interrelationship between some equipment, but not all equipment	understands interrelationship between equipment, but may require questioning	understanding of equipment interrelationship clearly demonstrated and presented without questioning	
Constraints/limitations of individual equipment and flowsheet understood	constraints/limitations not understood	very few constraints/limitations understood	some constraints/limitations understood	constraints/limitations understood, but may require questioning	understanding of constraints/limitations clearly demonstrated, without questioning	
Significance of conclusions understood	lack of understanding, no explanations	major gaps in understanding, few explanations	some gaps in understanding, some weak explanations	understood, but may require questioning	understanding clearly demonstrated, without questioning	

Attribute	0 (F) – Not proficient	1 (D) – Less than desired proficiency	2 (C) – Marginal proficiency	3 (B) – Good proficiency	4 (A) – Superior proficiency	Score
Apply chemistry, math, physics, life science, engineering science						
Apply engineering science	inability to apply principles	few basic principles applied	many principles applied, but some noticeable gaps	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to enhance design	
Apply chemistry	inability to apply principles	few basic principles applied	many principles applied, but some noticeable gaps	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to enhance design	
Apply physics	inability to apply principles	few basic principles applied	many principles applied, but some noticeable gaps	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to enhance design	
Apply life science	inability to apply principles	few basic principles applied	many principles applied, but some noticeable gaps	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to enhance design	
Apply mathematics	inability to apply principles	few basic principles applied	many principles applied, but some noticeable gaps	most principles applied, demonstration of effect on design	all principles applied and interwoven with engineering to enhance design	
Response to questions indicates ability to apply these principles	inability to apply principles demonstrated	few principles applied	many principles applied, but some noticeable	ability to apply most principles demonstrated and to	superior ability to apply all principles demonstrated and	

Attribute	0 (F) – Not proficient	1 (D) – Less than desired proficiency	2 (C) – Marginal proficiency	3 (B) – Good proficiency	4 (A) – Superior proficiency	Score
			gaps in understanding	explain impact on design of	clear explanations of impact on design	
Resolve complex problem into components and synthesize new result	inability to recognize component problems	recognizes a few component problems, little synthesis	recognizes many component problems and some synthesis done	breaks problem into most components and synthesizes new result	superior ability to break problem into all expected components and to synthesize new result	
Apply economic constraints, physical constraints, and optimization methods to obtain solution						
Show ability to use economics to drive solution to problem and focus on important parameters	economics not used to drive solution and/or to define key parameters	economics used sparingly to drive solution and/or to define key parameters	economics used to drive solution and/or to define some parameters	economics used to drive solution or to define key parameters	economics used to drive solution and to define key parameters	
Define objective function	no objective function used	objective function used, but inappropriate	objective function used, but inappropriate (but possibly more appropriate than D)	valid objective function used, but a more appropriate one could have been used	correct objective function used	
Define decision variables	no decision variables defined or used	inappropriate decision variables used	some valid decision variables used, but some omissions or some inappropriate	valid decision variables used, but some may be inappropriate	valid and appropriate decision variables used	

Attribute	0 (F) – Not proficient	1 (D) – Less than desired proficiency	2 (C) – Marginal proficiency	3 (B) – Good proficiency	4 (A) – Superior proficiency	Score
Correct use of optimization techniques	no optimization	some topological or parametric optimization used, but not both	topological and parametric optimization attempted, but errors	topological and parametric optimization done	use of topological and parametric optimization interwoven to obtain solution	
Computer usage						
Demonstrates use to solve problem	computer not used	computer used but major errors	computer used with some errors	computer used correctly	superior use of computer to obtain unique solution	
Demonstrated use to find information	information not found	computer used but major errors	computer used with some errors	computer used correctly	superior use of computer to obtain unique solution	
Critical analysis of computer results	no analysis, no results	no analysis, just presents results	little critical analysis	critical analysis of results, but missing features	good critical analysis of results	
Response to questions - technical						
Knowledge of ChE principles	does not demonstrate knowledge of ChE principles	significant gaps in knowledge of ChE principles demonstrated	basic knowledge of ChE principles, but some notable gaps	demonstrates good knowledge of ChE principles	demonstrates clear knowledge of ChE principles with a big-picture perspective	
Prompting required	cannot provide correct answers, even with prompting	can provide some correct answers with prompting	some correct answers provided without prompting,	correct answers provided with little or no prompting required	answers questions correctly without prompting, anticipates and	

Attribute	0 (F) – Not proficient	1 (D) – Less than desired proficiency	2 (C) – Marginal proficiency	3 (B) – Good proficiency	4 (A) – Superior proficiency	Score
			others require prompting		answers follow-up questions	
Application of safety principles (if applicable)	not done	poorly done, superficial analysis, few aspects considered	some aspects considered, not all considered in design	done well, typical aspects considered and applied to design	all usual and some unusual aspects considered, considerations clearly interwoven into design	
Other economic, global, societal, and legal considerations (if applicable)	not done	poorly done, superficial analysis, few aspects considered	some aspects considered, not all considered in design	done well, typical aspects considered and applied to design	all usual and some unusual aspects considered, considerations clearly interwoven into design	