

PROGRAM ASSESSMENT DATA AY2021

UNITED STATES MILITARY ACADEMY DEPARTMENT OF CHEMISTRY AND LIFE SCIENCE CHEMICAL ENGINEERING PROGRAM

May 24, 2022

<u>Student Outcome</u>	<u>Page</u>
1.....	<u>1</u>
2.....	<u>3</u>
3.....	<u>5</u>
4.....	<u>7</u>
5.....	<u>9</u>
6.....	<u>12</u>
7.....	<u>14</u>
8.....	<u>18</u>

Evaluations

Faculty.....	<u>22</u>
Advisory Board.....	<u>23</u>
Program Director	<u>24</u>

Level of Achievement of Student Outcome 1:

On completion of the chemical engineering program, our graduates will be able to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. Fundamentals of Engineering Examination, once/yr.
3. End-of-Semester Student Surveys, once/semester.
4. Chemical Engineering Program Exit Survey, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

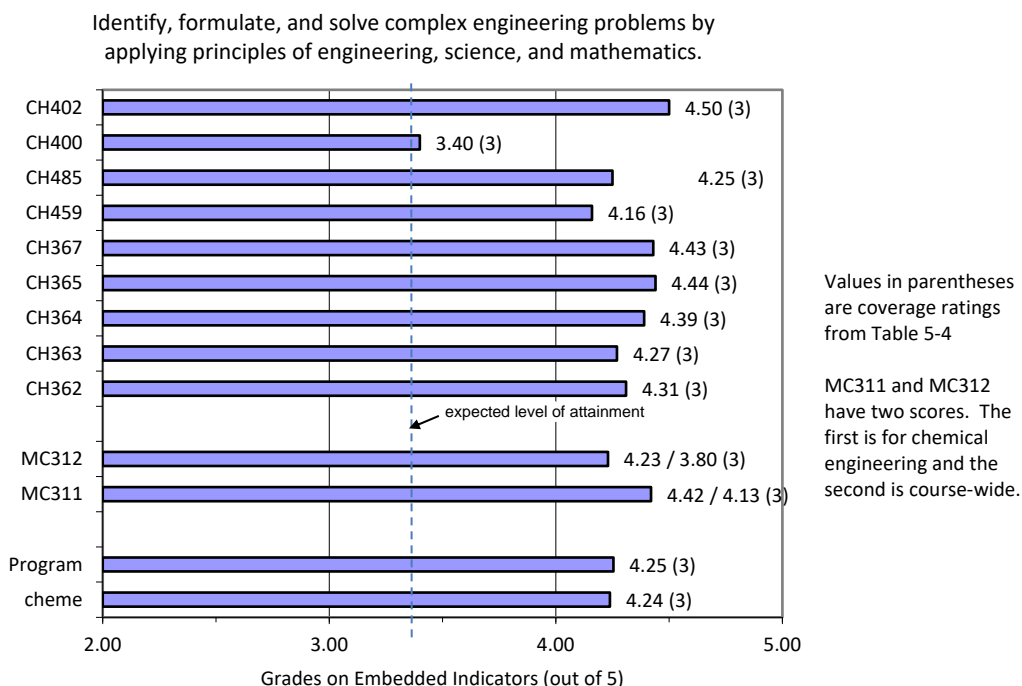


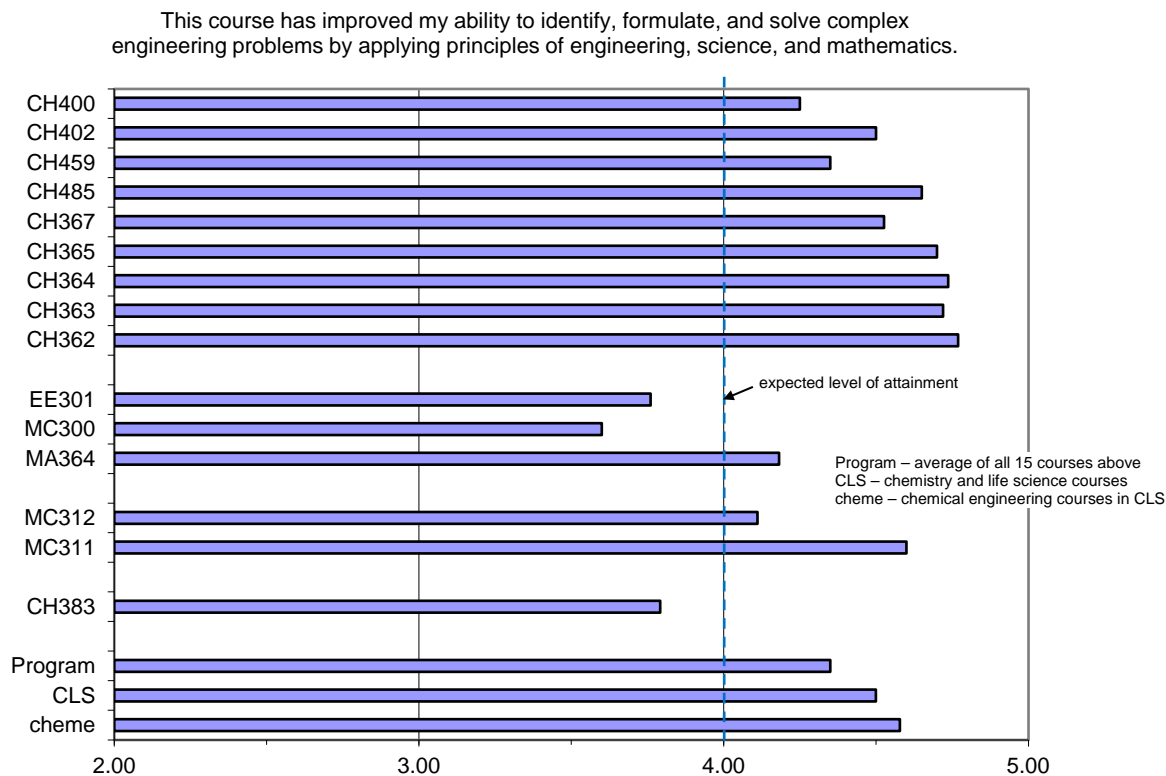
Figure 1-1. Coursework Embedded Indicator results for Student Outcome 1.

2. Fundamentals of Engineering Examination (FEE). According to the 2021 report from NCEES, 17 out of 20, or 85% of the students in the Class of 2021 took and passed the FE Exam. The national average passing in 2021 was 74.0%, and this is our expected level of attainment. In the previous five years, the pass rates were 77.8% in 2020, 100% in 2019, 85.7% in 2018, 93.8% in 2017, and 79.2% in 2016. Our running average over those five years is $87.3\% \pm 9.5\%$ ($76\% \pm 2\%$ for the national average).

Note: We are **above** the national average for the pass rate for the past six years, and the national average is our expected level of attainment.

3. End of Semester Student Surveys

Figure 1-2. End-of-Semester Student Survey responses for Student Outcome 1.



4. Chemical Engineering Program Exit Survey. This survey is issued to firsties at the end of their last semester. In this question, they were asked whether they agree with the statement “The program has prepared me to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.” 20 out of 20 cadets completed the survey. All 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 13/20 replying that they strongly agreed (score = 5/5) and 7/20 that they agreed (score = 4/5). This equates to a mean score of $4.65/5.00 \pm 0.49$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.

Level of Achievement of Student Outcome 2:

On completion of the chemical engineering program, our graduates will be able to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End of Semester Student Surveys, once/semester.
3. Course Grades in CH402 Chemical Engineering Process Design, once/yr.
4. Chemical Engineering Program Exit Survey, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

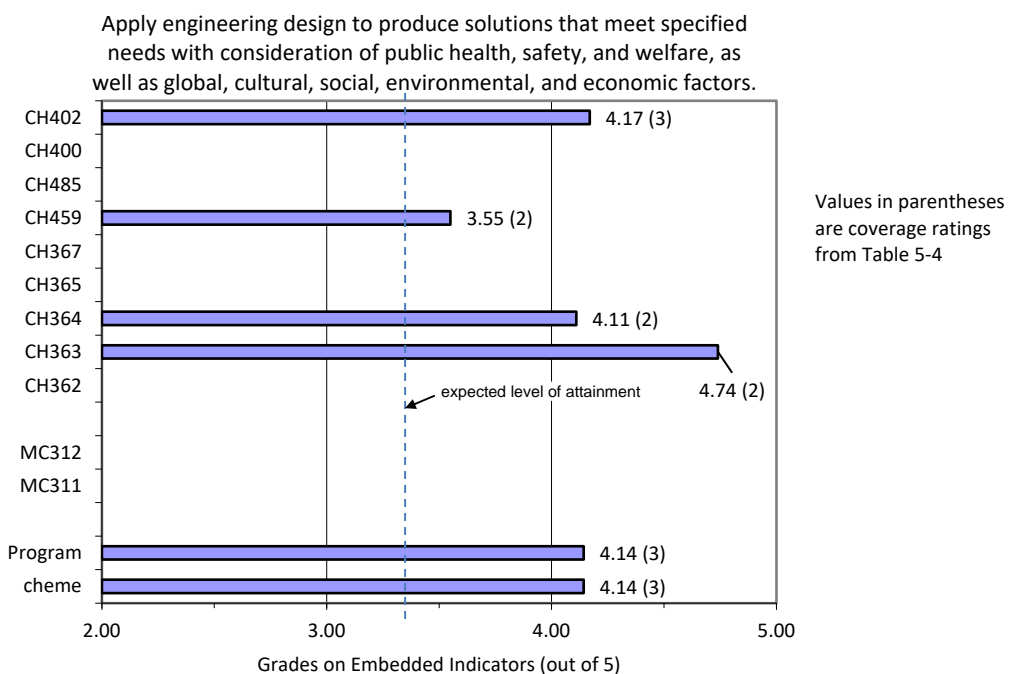


Figure 2-1. Coursework Embedded Indicator results for Student Outcome 2.

2. End of Semester Student Surveys

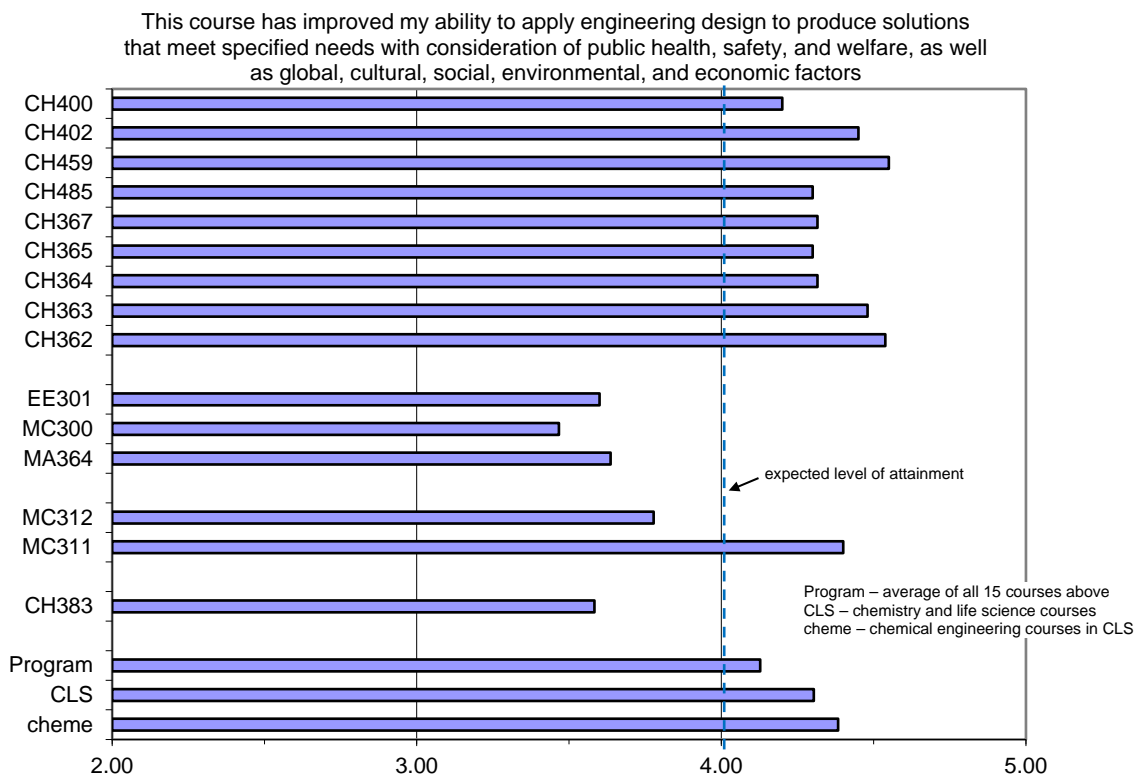


Figure 2-2. End-of-Semester Student Survey responses for Student Outcome 2.

3. The average course grade in CH402 Chemical Engineering Process Design was 3.46 ± 0.68 ($n=20$) in AY21, compared to 3.26 ± 0.70 ($n=29$) in AY20, 3.27 ± 0.92 ($n=21$) in AY19, 3.37 ± 0.66 ($n=19$) in AY18, 2.73 ± 0.39 ($n=16$) in AY17, and 3.43 ± 0.49 ($n=24$) in AY16. *The 5-year running average for the previous five years is 3.08, and this is our expected level of attainment. This year's score was above the 5-year running average.*
4. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to Firsties at the end of their last semester. In this question, they were asked whether or not they agree with the statement "The program has prepared me to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors." 20 out of 20 cadets completed the survey. Of these, 18 out of 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 10/20 replying that they strongly agreed (score = 5/5), 8/20 replying that they agreed (score = 4/5), and 2/20 that they were neutral (score = 3/5). This equates to a mean score of $4.40/5.00 \pm 0.68$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.

Level of Achievement of Student Outcome 3:

On completion of the chemical engineering program, our graduates will be able to communicate effectively with a range of audiences.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End of Semester Student Surveys, once/semester.
3. Course Grades in CH459 Unit Operations Laboratory, once/yr.
4. Chemical Engineering Program Exit Survey, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

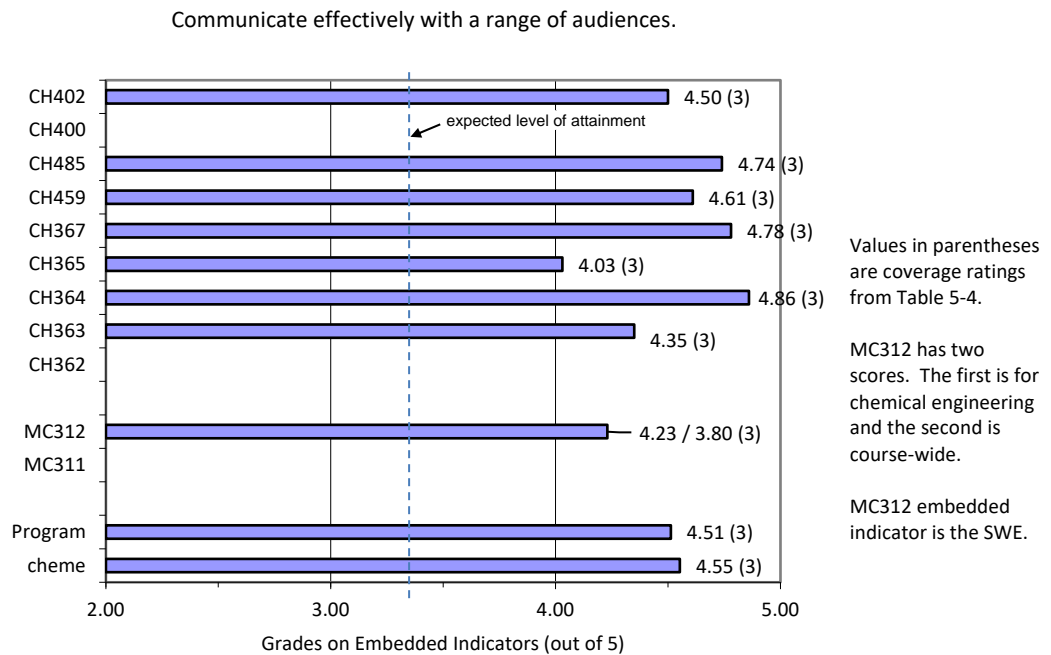


Figure 3-1. Coursework Embedded Indicator results for Student Outcome 3.

2. End of Semester Student Surveys

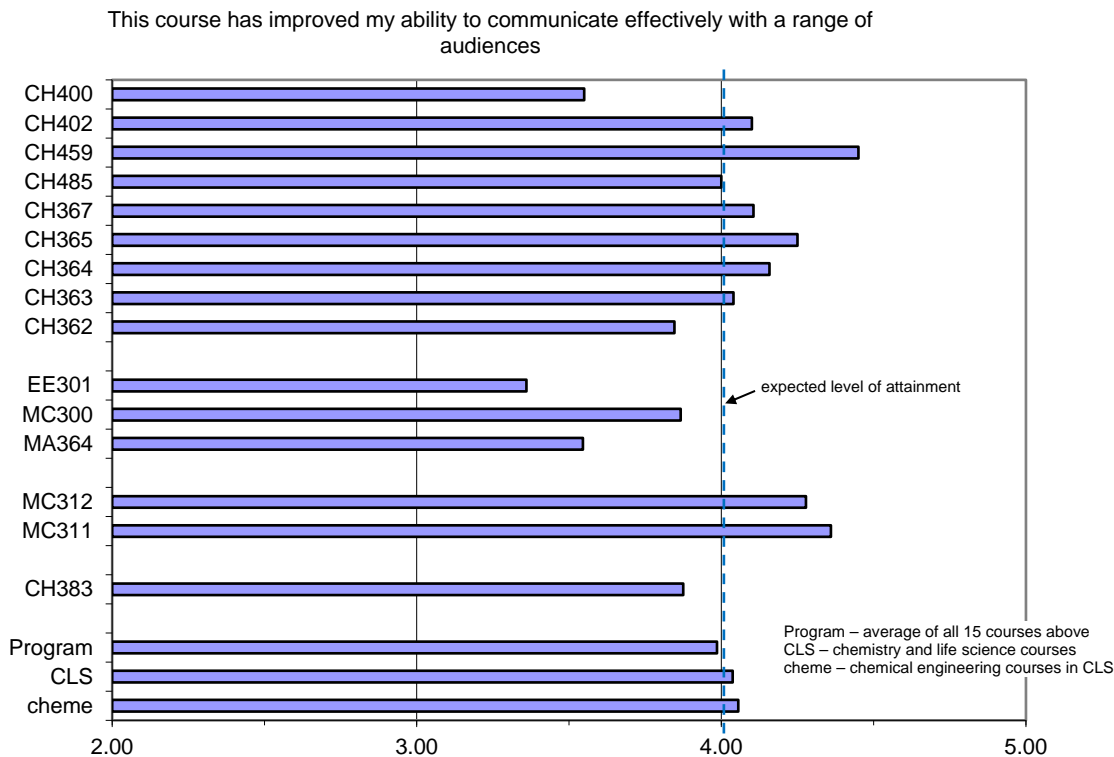


Figure 3-2. End-of-Semester Student Survey responses for Student Outcome 3.

3. The average course grade in CH459 Chemical Engineering Laboratory was 3.67 ± 0.75 ($n=20$) in AY21, compared to 3.53 ± 0.48 ($n=29$) in AY20, 3.52 ± 0.44 ($n=21$) in AY19, 3.42 ± 0.64 ($n=19$) in AY18, 3.54 ± 0.30 ($n=16$) in AY17, and 3.70 ± 0.35 ($n=23$) in AY16. *The 5-year running average is 3.57, and this is our expected level of attainment. This year's score was **above** the 5-year running average, which is a significant improvement.*
4. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to Firsties at the end of their last semester. In this question, they were asked whether they agree with the statement “The program has prepared me to communicate effectively with a range of audiences.” 20 out of 20 cadets completed the survey. Of these, 16 out of 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 7/20 replying that they strongly agreed (score = 5/5), 9/20 replying that they agreed (score = 4/5), and 4/20 replying that they were neutral (score = 3/5). This equates to a mean score of $4.15/5.00 \pm 0.75$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.

Level of Achievement of Student Outcome 4:

On completion of the chemical engineering program, our graduates will be able to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. Fundamentals of Engineering Examination Performance Index, once/yr.
3. End of Semester Student Surveys, once/semester.
4. Chemical Engineering Program Exit Survey, once/yr.
5. Completion of Cadet Character Education Program, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

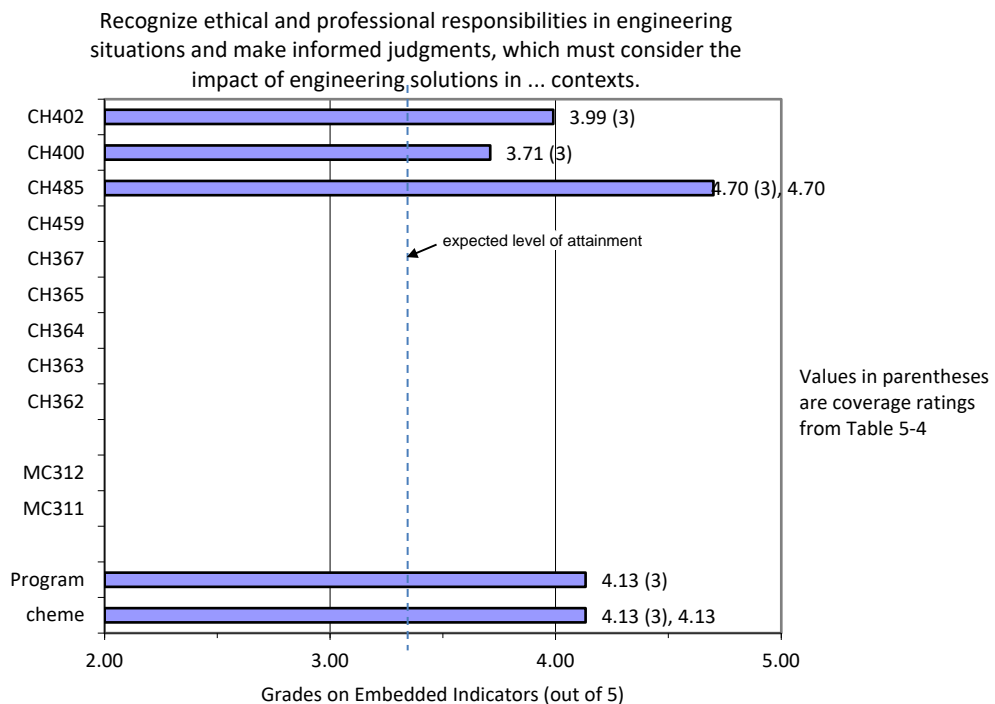


Figure 4-1. Coursework Embedded Indicator results for Student Outcome 4.

2. Fundamentals of Engineering Examination Performance, Self-Study Table 4-2.

Subject	Outcome	Questions	USMA	National (expected level of attainment)
Ethics and Professional Practice	4	3	12.9	11.7 ± 5.3
Economics	4	4	8.3	9.7 ± 3.8

Note: the national average is our expected level of attainment, and we are within the standard deviation reported by NCEES.

3. End of Semester Student Surveys

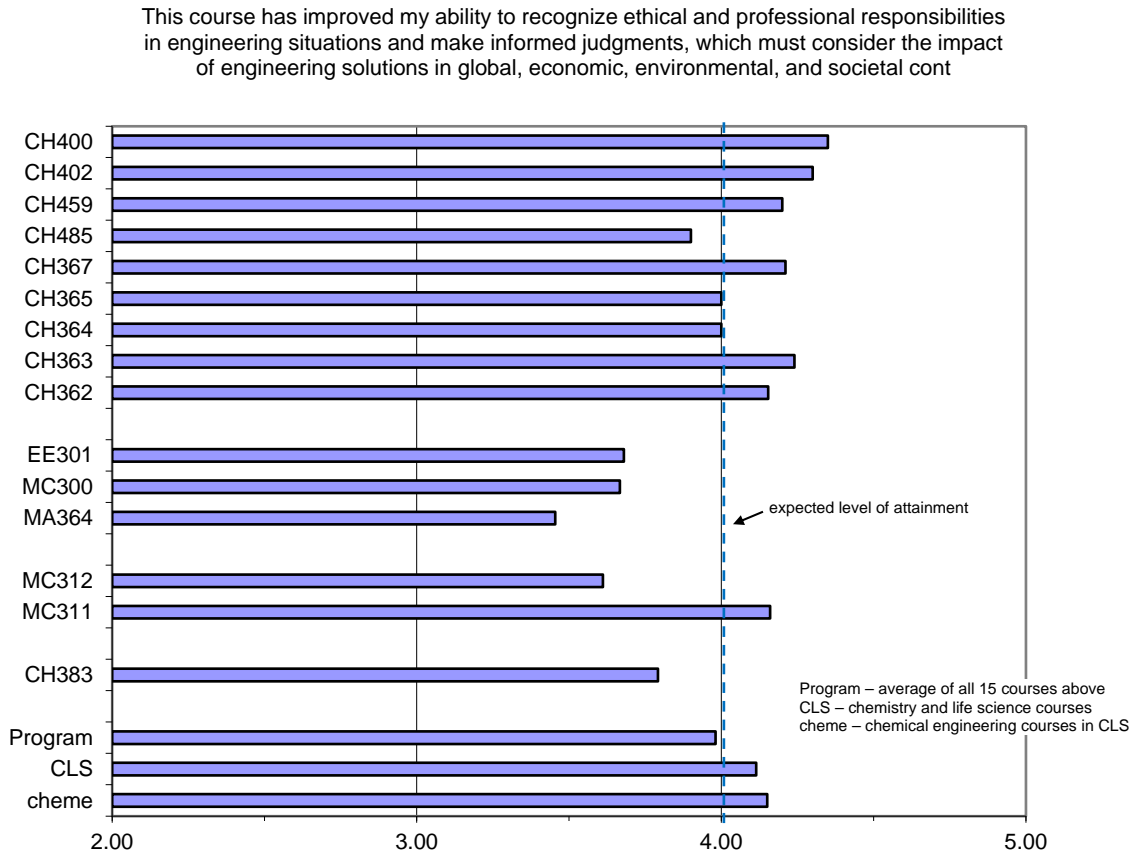


Figure 4-2. End-of-Semester Student Survey responses for Student Outcome 4.

4. Chemical Engineering Program Exit Survey. This survey is given to the Firsties at the end of their last semester. In this question, they were asked whether or not they agree with the statement “The program has prepared me to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.” 20 out of 20 cadets completed the survey. Of these, 19 out of 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 10/20 replying that they strongly agreed (score = 5/5), 9/20 replying that they agreed (score = 4/5), and 1/20 replying that they were neutral (score = 3/5). This equates to a mean score of $4.45/5.00 \pm 0.61$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.
5. Training in honor and ethics takes place in the Cadet Character Education Program (CCEP) during the academic year and summer terms. The program is overseen by the Commandant of Cadets through the Simon Center for the Professional Military Ethic. CCEP customizes instruction to each of the four year-groups of cadets, who interact with faculty volunteers who share their perspectives and experience in the Armed Forces, with industry, and at other civilian institutions. All 29 chemical engineering cadets successfully completed the 4-year CCEP program.

Level of Achievement of Student Outcome 5:

On completion of the chemical engineering program, our graduates will be able to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End of Semester Student Surveys, once/semester.
3. Chemical Engineering Program Exit Survey, once/yr.
4. Multidisciplinary Skills Rubric, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

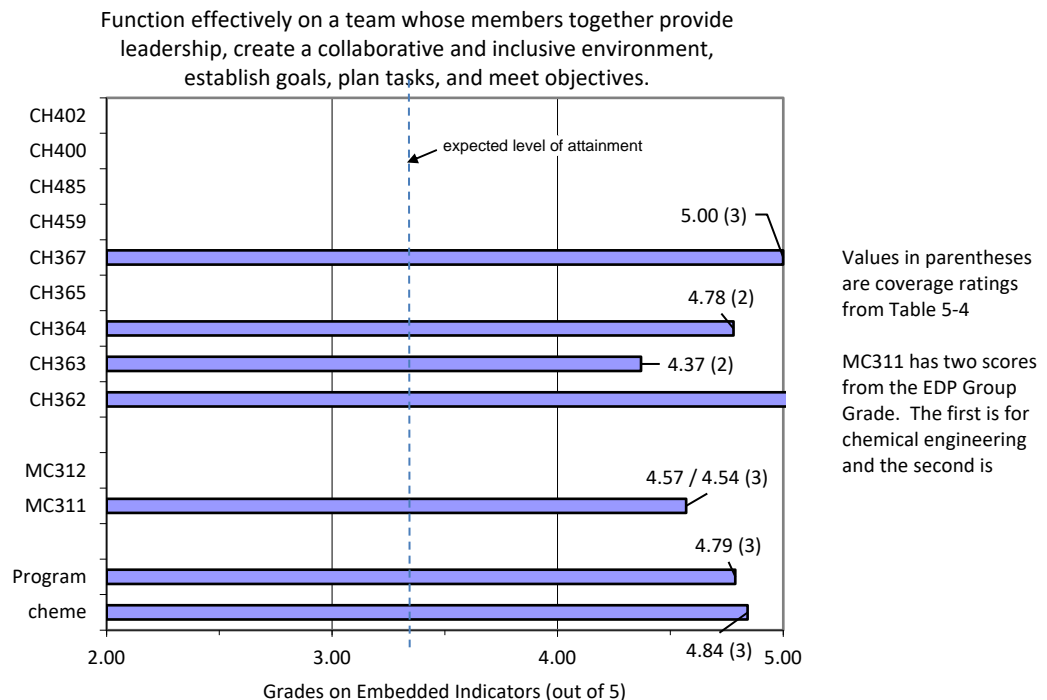


Figure 5-1. Coursework Embedded Indicator results for Student Outcome 5.

2. End of Semester Student Surveys

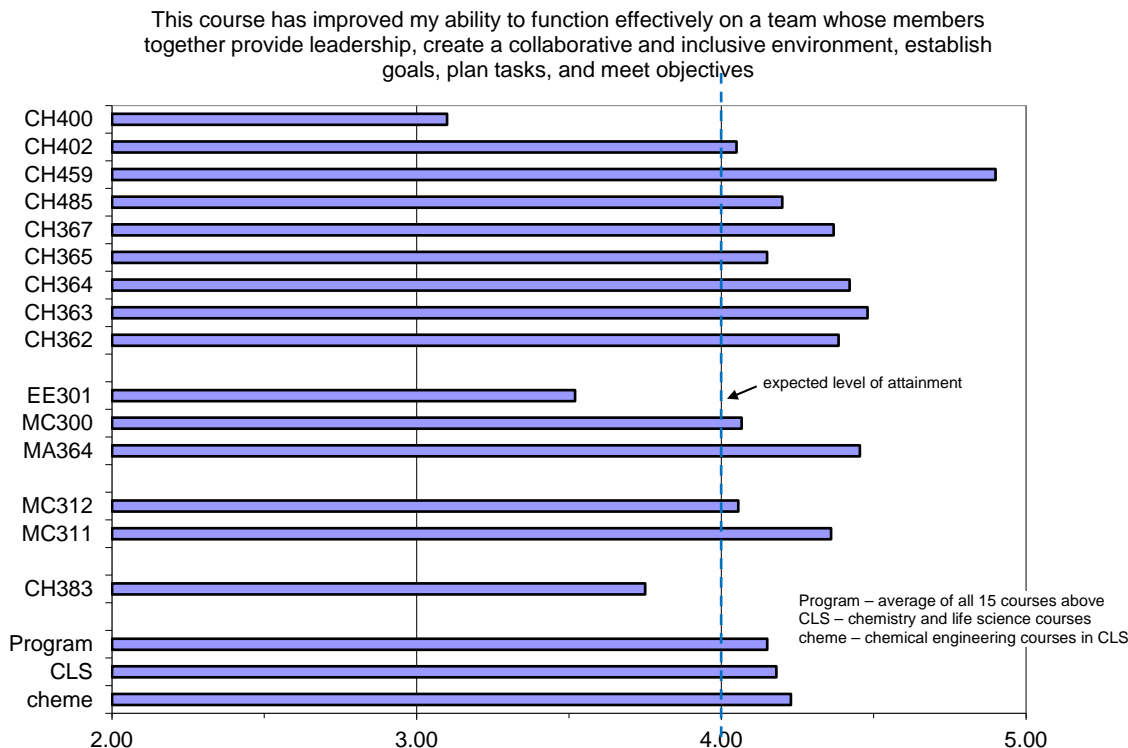


Figure 5-2. End-of-Semester Student Survey responses for Student Outcome 5.

3. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether or not they agree with the statement “The program has prepared me to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.” 20 out of 20 cadets completed the survey. Of these, 17 out of 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 11/20 replying that they strongly agreed (score = 5/5), 6/20 replying that they agreed (score = 4/5), and 3/20 replying that they were neutral (score = 3/5). This equates to a mean score of $4.40/5.00 \pm 0.75$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.
4. Teamwork Skills Rubric. The rubric is used to assess performance in four skills associated with the ability to function on effectively on a team, namely technical competence, communication, organization, and teamwork. The rubrics are completed by the cadets after each laboratory exercise in CH459. The results were averaged over each round-robin and reported below using the actual rubric for formatting. The superscript “a” next to the averages are for team assessment of the group leader (TAL) and “b” designates group leader assessment of the team (GLAT). The expected level of attainment is 4.0. The color shading indicates the

relationship of the averages to the expected level of attainment. Red shading indicates when improvement is needed.

Your Name: Dr. Enoch Nagelli				Person Assessed: Cadets in CH459					
Your Position: CH459 CD				Major of Person Assessed: Chemical Engineering					
	1 – Needs Improvement	1	2	3 – Meets Expectations	3	4	5 – Exceeds Expectations	5	N/A
Technical Competence	Some misunderstandings of the technical content.			Demonstrated knowledge of the technical content.			Exceptional knowledge of technical content.	4.6 ^a ±.51 ^c 4.9 ^b ±.23 ^c	
Communication	Lacked sensitivity and/or did not provide specific suggestions for improvement.			Effectively communicated important points.			Exceptional ability to explain important points. Very effectively communicated ideas for improvement.	4.6 ^a ±.19 ^c 4.9 ^b ±.23 ^c	
Organization	Was not prepared or did not give sufficient time to prepare.			Demonstrated effective organization during class.			Was exceptionally efficient, timely and responsive throughout the entire process.	4.6 ^a ±.15 ^c 4.9 ^b ±.23 ^c	
Teamwork	Demonstrated limited ability to see other perspectives or find common ground.			Worked collaboratively with team members to reach consensus.			Exceptional ability to help group find common ground or resolve conflict in order to ultimately reach consensus.	4.6 ^a ±.16 ^c 4.8 ^b ±.28 ^c	
Are the cadets capable of functioning on multidisciplinary teams? Yes	Comments: Each cadet was group leader twice. Footnote “a” designates the average of all Team Assessments of Leader (TAL) scores, while “b” designates average of all Group Leader Assessment (GLAT) scores. Footnote “c” designates standard deviations.						Assignment used for assessment: AY21, Round Robin 1		

Your Name: Dr. Enoch Nagelli				Person Assessed: Cadets in CH459					
Your Position: CH459 CD				Major of Person Assessed: Chemical Engineering					
	1 – Needs Improvement	1	2	3 – Meets Expectations	3	4	5 – Exceeds Expectations	5	N/A
Technical Competence	Some misunderstandings of the technical content.			Demonstrated knowledge of the technical content.			Exceptional knowledge of technical content.	4.8 ^a ±.06 ^c 4.6 ^b ±.2 ^c	
Communication	Lacked sensitivity and/or did not provide specific suggestions for improvement.			Effectively communicated important points.			Exceptional ability to explain important points. Very effectively communicated ideas for improvement.	4.8 ^a ±.09 ^c 4.8 ^b ±.18 ^c	
Organization	Was not prepared or did not give sufficient time to prepare.			Demonstrated effective organization during class.			Was exceptionally efficient, timely and responsive throughout the entire process.	4.8 ^a ±.05 ^c 4.7 ^b ±.21 ^c	
Teamwork	Demonstrated limited ability to see other perspectives or find common ground.			Worked collaboratively with team members to reach consensus.			Exceptional ability to help group find common ground or resolve conflict in order to ultimately reach consensus.	4.8 ^a ±.05 ^c 4.9 ^b ±.09 ^c	
Are the cadets capable of functioning on multidisciplinary teams? Yes	Comments: Each cadet was group leader twice. Footnote “a” designates the average of all Team Assessments of Leader (TAL) scores, while “b” designates average of all Group Leader Assessment (GLAT) scores. Footnote “c” designates standard deviations.						Assignment used for assessment: AY21, Round Robin 2		

Level of Achievement of Student Outcome 6:

On completion of the chemical engineering program, our graduates will be able to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End-of-Semester Student Surveys, once/semester.
3. Chemical Engineering Program Exit Survey, once/yr.
4. Course Grades in CH459 Unit Operations Laboratory, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

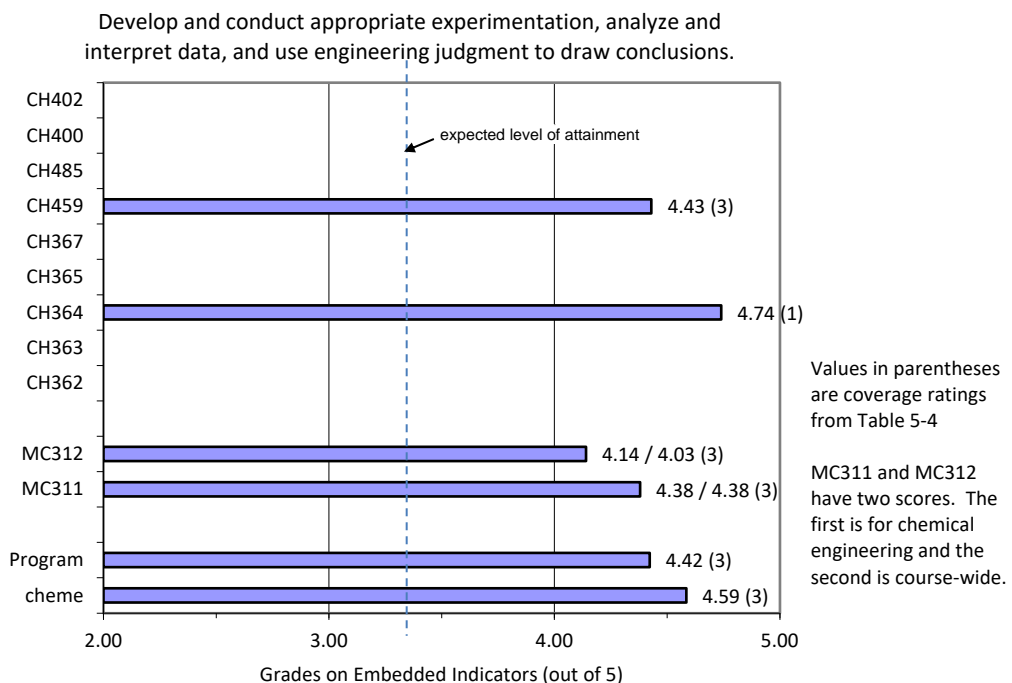


Figure 6-1. Coursework Embedded Indicator results for Student Outcome 6.

2. End of Semester Student Surveys

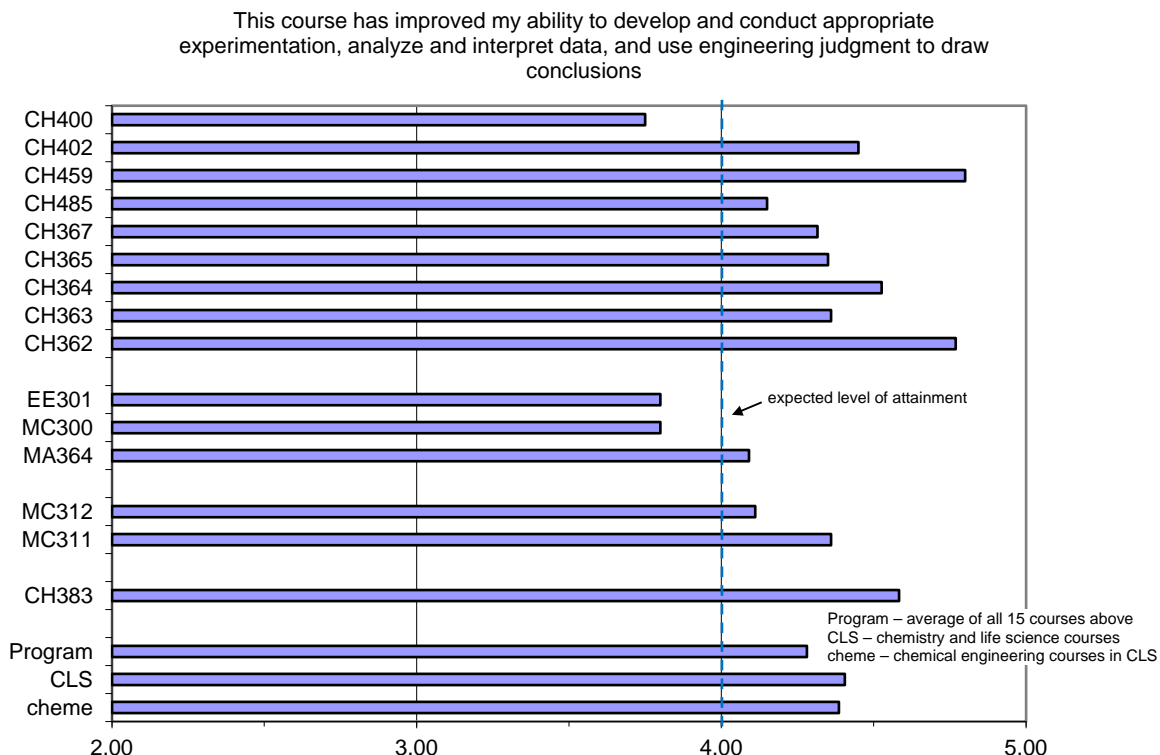


Figure 6-2. End-of-Semester Student Survey responses for Student Outcome 6.

3. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether they agree with the statement “The program has prepared me to Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.” 20 out of 20 cadets completed the survey. Of these, 16 out of 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 9/20 replying that they strongly agreed (score = 5/5), 7/20 replying that they agreed (score = 4/5), and 4/20 replying that they were neutral (score = 3/5). This equates to a mean score of $4.25/5.00 \pm 0.77$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.
4. The average course grade in CH459 Chemical Engineering Laboratory was 3.67 ± 0.75 (n=18) in AY21, compared to 3.53 ± 0.48 (n=29) in AY20, 3.52 ± 0.44 (n=21) in AY19, 3.42 ± 0.64 (n=19) in AY18, 3.54 ± 0.30 (n=16) in AY17, and 3.70 ± 0.35 (n=23) in AY16. The 5-year running average is 3.57, and this is our expected level of attainment. This year’s score was **above** the 5-year running average, which shows significant improvement.

Level of Achievement of Student Outcome 7:

On completion of the chemical engineering program, our graduates will be able to acquire and apply new knowledge as needed, using appropriate learning strategies.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. Percent of eligible students taking the Fundamentals of Engineering Examination (FEE), once/yr.
3. End of Semester Student Surveys, once/semester.
4. Chemical Engineering Program Exit Survey, once/yr.
5. Lifelong Learning Skills Rubric, twice per year.
6. Contemporary Issues Rubric, multiple times per year.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

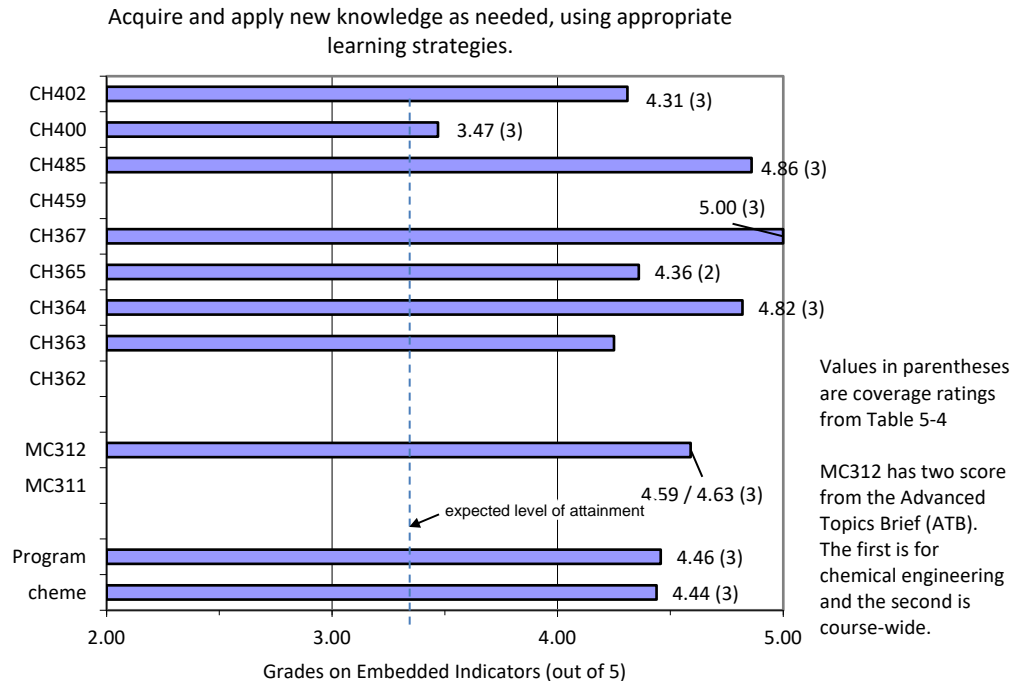


Figure 7-1. Coursework Embedded Indicator results for Student Outcome 7.

2. Percent of Eligible Cadets taking the Fundamentals of Engineering Examination (FEE). For the Class of 2021, 20 of 20 chemical engineering cadets (100% of eligible cadets) prepared for and took the FEE. This compares to 100% from years 2015 to 2019, with 31% in 2020 (9 of 29). The decline in participation in 2020 was due to closure of NCEES test centers nationwide in addition to restrictions on cadet movement during the COVID-19 crisis. NCEES reported a decline from 1047 in 2019 to 480 in 2020, which recovered somewhat to 668 in 2021. **Note: The participation rate is EXCELLENT.**

3. End of Semester Student Surveys

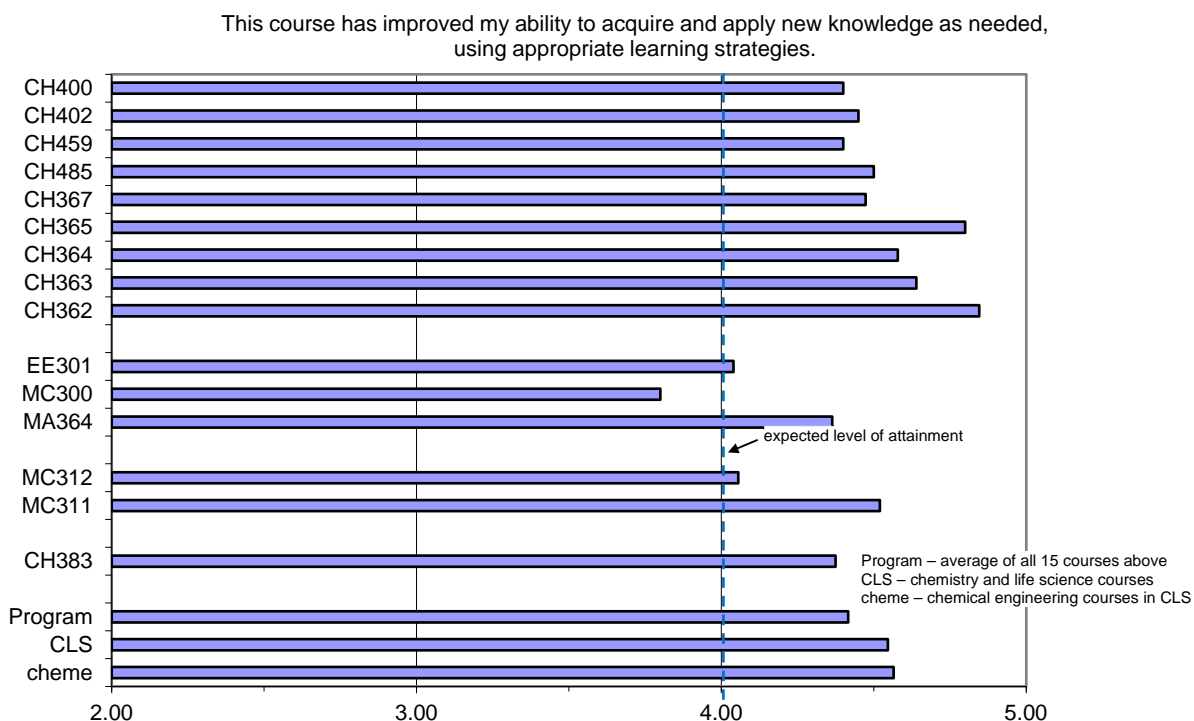


Figure 7-2. End-of-Semester Student Survey responses for Student Outcome 7.

4. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the firsties at the end of their last semester. In this question, they were asked whether they agree with the statement “The program has prepared me to Acquire and apply new knowledge as needed, using appropriate learning strategies.” 20 out of 20 cadets completed the survey. All 20 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 13/20 replying that they strongly agreed (score = 5/5) and 7/20 that they agreed (score = 4/5). This equates to a mean score of $4.65/5.00 \pm 0.49$ for the 20 cadets. The expected level of attainment on this survey is 4.00/5.00.
5. Lifelong Learning Skills Rubric. This rubric, when used in tandem with the resume writing assignment in CH365, is designed to assess performance in four skills associated with the ability to acquire new knowledge, namely: rubric row 1 - engagement (in professional activities), rubric row 2 - recognition (of skills learned in the program), rubric row 3 – intellectual growth (recognition of new skills), and rubric row 4 – communication (in resume format). Resumes were written at the beginning of the semester (assignment 1.1), revised (assignment 1.2), then revised again at the end of the semester (assignment 2.0). One rubric is shown for each assignment below, along with cadet averages and standard deviations. The expected levels of attainment are color-coded, with red indicating a need for

improvement, yellow indicating acceptable performance, and green indicating that expectations are met or exceeded. Instructor comments are in the rubrics.

Instructor's Name: Biaglow				Cadet Assessed: All cadets in CH365				
Your Position: Instructor, CH365 (e.g., CD CH365)				Cadet Major: Chemical Engineering (e.g., Chem. Eng.)				
	1 – Needs Improvement	1	2	3 – Meets Expectations	3	4	5 – Exceeds Expectations	5
Engagement Outcome 7	No evidence of pre-professional activities.			References to pre-professional activities are lacking or connections to chemical engineering are weak or implied.		4.5 +/- 0.6	Uses examples of pre-professional chemical engineering activities.	
Recognition Outcome 7	Skills learned in chemical engineering courses taken in previous semesters are not listed.			Skills are listed, but the skills are vaguely described, or connection to chemical engineering concepts is not clear.		4.2 +/- 0.6	Identifies specific skills learned in chemical engineering courses.	
Intellectual Growth Outcome 7	Unable to identify new concepts learned this semester.			Changes are apparent in document, but connections to recent activities in chemical engineering are weak or implied.	3.3 +/- 1.0		Addition of multiple skills acquired this semester.	
Communication Outcome 3	Resume lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Target audience unclear.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic resume, but document is uninteresting and flat.		4.4 +/- 0.7	Demonstrates an ability to effectively communicate in the resume format. Clear, concise content. Resume is interesting.	
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Scores were much higher this year due to heavy feedback to the cadets and to the use of targeted reference materials to help them focus on the assigned categories. Final Grade: 4.1 +/- 0.9 / 5						Assignment used for assessment: (e.g., resume draft 1.1 in CH365) resume draft 1.1 in CH365	

Instructor's Name: Biaglow				Cadet Assessed: All cadets in CH365				
Your Position: Instructor, CH365 (e.g., CD CH365)				Cadet Major: Chemical Engineering (e.g., Chem. Eng.)				
	1 – Needs Improvement	1	2	3 – Meets Expectations	3	4	5 – Exceeds Expectations	5
Engagement Outcome 7	No evidence of pre-professional activities.			References to pre-professional activities are lacking or connections to chemical engineering are weak or implied.			Uses examples of pre-professional chemical engineering activities.	4.8 +/- 0.4
Recognition Outcome 7	Skills learned in chemical engineering courses taken in previous semesters are not listed.			Skills are listed, but the skills are vaguely described, or connection to chemical engineering concepts is not clear.		4.5 +/- 0.6	Identifies specific skills learned in chemical engineering courses.	
Intellectual Growth Outcome 7	Unable to identify new concepts learned this semester.			Changes are apparent in document, but connections to recent activities in chemical engineering are weak or implied.		4.4 +/- 0.6	Addition of multiple skills acquired this semester.	
Communication Outcome 3	Resume lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Target audience unclear.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic resume, but document is uninteresting and flat.		4.5 +/- 0.5	Demonstrates an ability to effectively communicate in the resume format. Clear, concise content. Resume is interesting.	
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Generally, scores were higher on this draft due to feedback incorporated from the earlier draft.. All scores are "in the green." Final Grade: 4.5 +/- 0.5 / 5						Assignment used for assessment: (e.g., resume draft 1.1 in CH365) resume draft 2.0 in CH365	

There is normally improvement in scores in draft 2.0 as cadets incorporated instructor comments to improve and polish their documents. Version 2.0, though, requires articulation of new skills acquired during the semester. Scores can go down if cadets do not show new activities and skills, and some individual cases the scores did drop. However, overall and on average, the program scores are solidly in the green in all four categories by the end of the semester.

6. Contemporary Issues Rubric.

Instructor's Name: LTC Cowart				Cadet Assessed: All Cadets in CH485				
Your Position: CD, CH485 (e.g., CD CH485)				Cadet Major: Chemical Engineering (e.g., Chem. Eng.)				
	1 – Needs Improvement	1	2	3 – Meets Expectations	3	4	5 – Exceeds Expectations	5
Acquiring Knowledge Outcome 7	Cites references but they are not substantive or do not address assignment. Context is weak or implied. Uses generic arguments or lacks specificity.			Cites at least two references relevant to the assignment. References have been adequately studied and reworded to support a thesis.			Uses multiple substantive examples or scholarly articles in an integrative fashion to support a thesis.	4.8 +/- 0.5
Technical Competence Outcomes 8	Demonstrates poor or incomplete understanding of technical content.			Demonstrates some knowledge of the technical content, but explanation lacks adequate depth.		4.2 +/- 0.7	Demonstrates exceptional knowledge of technical content.	
Synthesis of Ideas Outcome 3	Does not have a premise or does not connect issues in essay to concepts in chemical engineering.			Makes connections to chemical engineering concepts, but the connections are weak or implied or premise is weak.			Makes very clear connections between premise and chemical engineering concepts.	4.7 +/- 0.6
Grammar and Structure Outcome 3	Lacks organization or cohesion. Numerous grammatical errors or errors interfere with meaning. Thesis lacking or implied.			Occasional grammar that do not impede meaning. Demonstrates ability to write an essay but lacks cohesion or completeness. Thesis not fully supported.			Demonstrates an ability to effectively communicate in the essay format. Fully supported, clear, concise thesis. Writing style was exceptionally clear and articulate.	4.8 +/- 0.5
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Overall solid performance by the entire class. Cadets demonstrated acquisition of new knowledge and generally wrote in an acceptable format. Bonus points were awarded (not counted here) for formatting their paper in an article format. Overall technical content with respect to heat & mass transfer can be improved.						Assignment used for assessment: (e.g., draft 1 writing assignment 1 in CH485) CH485 Writing Final	
	Final Grade: 4.6 +/- 0.6							

The contemporary issues rubric is designed to assess performance in four skills associated with the ability to acquire new knowledge, namely: rubric row 1 - acquiring knowledge (through development and use of references), rubric row 2 - technical competence of the cadet (as demonstrated with writing skills), rubric row 3 - synthesis of ideas (into a coherent essay), and rubric row 4 - grammar and structure. Each of these skills, taken independently, are associated with written communication (Student Outcome 3). However, the development and blending of these skills into a coherent and well-crafted essay are a measure of acquisition of new knowledge and are thus used by our program to assess Student Outcome 8. Admittedly, this is not a complete measure of a student's ability to acquire new knowledge, only that ability as expressed in an essay. Therefore, we combine this exercise with the other embedded indicators in this section of the report.

Operationally, the contemporary issues rubric is completed by the instructor to award grades to cadets for the writing assignments in this course. In this case, LTC Cowart used one writing assignment in CH485, but completed in two drafts. He did not grade the first draft the same way he graded the final submission. The draft (75 points) was graded as a whole document; if they submitted a complete draft that he could review and make recommendations, then cadets received 75 points. Points were only deducted when a draft was missing a key element of the assignment. The average for the draft was 4.87 ± 0.26 , so they achieved a better average on the draft than on the final submission. The final submission was graded against the rubric, with the total average score and average scores per outcome shown in the figure above.

Level of Achievement of Student Outcome 8:

The program provides the graduate with a thorough grounding and working knowledge of the chemical sciences, including:

- (8.1) Chemistry.
- (8.2) Material and energy balances
- (8.3) Safety and environmental factors.
- (8.4) Thermodynamics of physical and chemical equilibria.
- (8.5) Heat, mass, and momentum transfer.
- (8.6) Chemical reaction engineering.
- (8.7) Continuous and staged separation operations.
- (8.8) Process dynamics and control.
- (8.9) Modern experimental and computing techniques.
- (8.10) Process design.

Assessment Instruments and Frequency:

1. Fundamentals of Engineering Examination, once/yr.
2. Average Course Grades for Chemical Engineering Students, once/yr.

Assessment Results:

1. Fundamentals of Engineering Examination, Table 4-14. For the Class of 2021, the breakdown by topic is shown in comparison to the national averages.

Subject	Outcome	Questions	USMA ChE	National (expected level of attainment)
Chemistry & Biology	8.1	6	9.7	10.1±3.3
Material & Energy Balances	8.2	10	9.4	9.1±2.3
Safety, Health, & Environmental	8.3	5	9.9	10.0±3.2
Thermodynamics	8.4	8	9.2	9.3±2.0
Heat Transfer	8.5	8	9.5	9.9±2.5
Fluid Mechanics/Dynamics	8.5	8	8.6	9.6±2.5
Chemical Reaction Engineering	8.6	7	9.5	9.7±2.5
Mass Transfer & Separations	8.7	8	9.5	9.6±2.1
Process Control	8.8	4	9.8	9.9±3.5
Computational Tools	8.9	0	---	---
Economics	8.10	8	8.3	9.7±3.8
Process Design	8.10	7	9.7	9.9±2.7

2. Course grades for the last six years are shown below, Table 4-4 (from Self Study).

Course ↓		Chemical Engineering Student Outcome 8								
		Advanced Chemistry	Mater. & Energy Bal.	Thermodynamics	Transport	Reaction Engineering	Separations	Dynamics & Control	Experiment & Compute	Process Design
		8.1	8.2	8.4	8.5	8.6	8.7	8.8	8.9	8.10
CH383	Organic Chemistry I	2.78								
CH365	Chem. Eng. Thermo.			3.56						
CH362	Mass & Energy Balances		3.54							
CH363	Separation Processes						3.37			
CH364	Chem. Reaction Eng.					3.31				
CH459	Chem. Eng. Laboratory								3.67	
CH485	Heat and Mass Transfer				3.26					
CH400	Chemical Engineering Sem.									
CH402	Chem. Eng. Process Des.									3.46
MA366	Vector Calculus									
ME311	Thermal-Fluid Systems I			3.24	3.24					
ME312	Thermal-Fluid Systems II			3.05	3.05					
CE300	Fund. Eng. Mech. & Des.									
EE301	Intro. To Elec. Engineering									
CH367	Intro. Auto. Process Control							3.35		
Average Grade 2021		2.78	3.54	3.33	3.23	3.31	3.37	3.35	3.67	3.46
Average Grade 2020		3.06	3.53	3.27	3.20	3.38	3.64	3.36	3.53	3.26
Average Grade 2019		3.14	3.63	3.69	3.39	3.67	3.92	3.51	3.52	3.26
Average Grade 2018		2.87	3.72	3.51	3.20	3.66	3.67	3.53	3.42	3.37
Average Grade 2017		3.15	3.21	3.65	3.25	3.66	3.67	3.31	3.54	2.73
Average Grade 2016		3.19	3.57	3.43	3.32	3.64	3.57	3.55	3.70	3.43
<i>Previous 5-year Running Average (expected level of attainment)</i>		3.05	3.53	3.51	3.27	3.60	3.69	3.45	3.54	3.21
Standard Deviation 2020		0.81	0.64	0.76	0.74	0.75	0.68	0.74	0.75	0.68

Table 4-2. Faculty Evaluation of Chemical Engineering Student Outcomes

Chemical Engineering Student Outcomes	Faculty Evaluation
On completion of the chemical engineering program, our graduates are able to:	
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	5.00 \pm 0.00
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	4.60 \pm 0.52
3. Communicate effectively with a range of audiences.	4.40 \pm 0.70
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	4.80 \pm 0.42
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	5.00 \pm 0.00
6. Develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.	4.80 \pm 0.42
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.60 \pm 0.52
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	4.80 \pm 0.42
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

The faculty scores are complete as of 15 September 2021.

Table 4-3. Advisory Board Evaluation of Chemical Engineering Student Outcomes

Chemical Engineering Student Outcomes	Advisory Board's Evaluation
On completion of the chemical engineering program, our graduates are able to:	
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	5.00 ± 0.00
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	4.55 ± 0.52
3. Communicate effectively with a range of audiences.	4.59 ± 0.49
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	4.64 ± 0.50
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	4.82 ± 0.40
6. Develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.	4.55 ± 0.50
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.73 ± 0.47
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	4.95 ± 0.15
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

Note: These are complete as of 24 May 2022. Entries are for AY21 assessment and are from the most recent advisory board review on April 7-8, 2022. New data from the 2023 advisory board will be entered after the next review in Spring of 2023 for submission to the AY22 EXSUM.

Table 4-4. Summary of Chemical Engineering Student Outcomes Performance.

Chemical Engineering Student Outcomes	Program Director's Summary
On completion of the chemical engineering program, our graduates are able to:	
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	5
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	5
3. Communicate effectively with a range of audiences.	5
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	5
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	5
6. Develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.	5
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	5
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	5
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

These PD entries are preliminary estimates only as of 24 May 2022.